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Final Report of Free Breathing Static Dehumidification Systems

HQ AFLC/DSTZ
AIR FORCE PACKAGING EVALUATION AGENCY
Wright-Patterson AFB OH 45433-5999

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AFPEA PROJECT NO. 86-P-311

TITLE: Engineering Support for the Free Breathing Static Dehumidification (FBSDH) System

ABSTRACT

Deterioration of materiel from moisture induced corrosion in shelters/trailers/vans (S/T/Vs) during shipping/storage led to the development of a self-contained system designed to maintain a relative humidity (RH) of 40 percent or less within a S/T/V for a period of two years without desiccant changes. This particular system is static because there is no external means to generate its operation of maintaining the RH of 40 percent or less.

Six prototype FBSDH systems were fabricated under contract number 33700-81-C-0074. Five units were placed in a field service test at SM-ALC/DSTD, McClellan AFB CA and one unit was placed in a field service test at HQ AFLC/DSTZ, Wright-Patterson AFB ~~OH~~. The field test operation was established to verify the prototype design and to determine the actual life of the desiccant charge.

The field test data shows ~~that~~ the prototype FBSDH system did not verify the design requirement of maintaining a 40 percent or less RH in the interior of the S/T/Vs. ~~However,~~ it is anticipated ~~that~~ the FBSDH system will maintain ~~the~~ 40 percent or less RH level when ~~properly~~ installed in equipment or containers ~~that are~~ designed to meet the requirement of 2.0 inches of water pressure (0.072 pounds per square inch) for 60 minutes.

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TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

EXECUTIVE SUMMARY

The Air Force has long recognized the need for environmental protection of materiel in shelters/trailers/vans (S/T/Vs) during shipping/storage. Deterioration of materiel from corrosion, due to the presence of excessive moisture in S/T/Vs results in high maintenance costs to the US Government.

The moisture problem has been addressed at various times in the past years; however, the goals to meet the operating and design requirements have fallen short of providing state-of-the-art environmental protection for equipment. Variables such as the quantity of desiccant required, the effective placement of desiccant, and the service life of the desiccant, have not been fully explored.

A self-contained, modular unit was developed under contract to provide a dry storage environment for materiel inside of S/T/Vs by maintaining a relative humidity (RH) of 40 percent or less for a period of two years without desiccant changes.

Field test operations were established with five shelters at SM-ALC/DSTD and one shelter at HQ AFLC/DSTZ to verify the prototype design and to determine the actual life of the desiccant charge. It should be noted that the S/T/Vs used at SM-ALC/DSTD were not new shelters, but were reconditioned in an extensive sealing operation to reduce the amount of leakage into the S/T/V. Consequently, the field test operation was initiated with less than ideal S/T/Vs with the best effort conditions.

Results of the field test, 15 Jan 85 through 31 Oct 86, indicate that the design of the prototype FBSDH system did not verify the design requirements by maintaining a RH of 40 percent or less in the S/T/Vs. However, it is anticipated that the FBSDH system will maintain the 40 percent or less RH level when properly installed in equipment of containers that are designed to be air tight and can meet the requirement of 2.0 inches of water pressure (0.072 pounds per square inch) for 60 minutes.

INTRODUCTION

BACKGROUND: During storage and transportation of S/T/Vs, proper corrosion control is not always accomplished, resulting in repair/replacement of electronic items in S/T/Vs. A prototype FBSDH system has been developed under contract to reduce humidity and prevent water induced corrosion of electronic equipment housed in S/T/Vs.

Preliminary design parameters for the FBSDH system were established from published literature on dehumidification systems. The conceptual design was developed and laboratory tested to verify design criteria. An estimated two year service life for the desiccant charge was derived from the laboratory tests. To determine the actual service life of the desiccant, field test operations were established at SM-ALC/DSTD, McClellan AFB CA and HQ AFLC/DSTZD, Wright-Patterson AFB OH.

The FBSDH system was designed to be effective for a S/T/V size of 8'x8'x10' (640 cu ft). The FBSDH system is a self-contained modular unit which allows air flow through the unit when placed in a sealed S/T/V during shipment/storage. This air flow (or breathing) is created by changing environmental conditions. The FBSDH system is a static system because air is not circulated by dynamic dehumidification machines or fans.

The components of the system are suitable for use in an environment of -40 degree F (-40 degree C) to +155 degree F (+68 degree C). The system is designed for a breathing cycle of 90 degree F at 95 percent RH to +120 degree F at 40 percent RH with five hours of in-breathing and five hours of out-breathing during each 24 hour period.

For a FBSDH system to work, all breathing air in and out of the S/T/V must pass through the FBSDH system. Therefore, the S/T/V must be adequately sealed to ensure that all breathing in and out of the S/T/V is only through the FBSDH system.

The FBSDH system is designed to be easily installed and removed from a S/T/V (see Appendix A). The only modification required to a S/T/V is to cut a hole in the wall or door to install the FBSDH system. Also, the system can be completely serviced without opening the S/T/V.

PURPOSE: The purpose of the field service test project was to verify the prototype design of the FBSDH system and to determine the actual life of the desiccant charge.

TEST SPECIMENS: Six systems (Figures 1 through 6 and Appendix B) were fabricated under Air Force contract number 33700-81-C-0074 by AGM Container Controls, Inc., 3526 E. Lowell Road, P.O. Box 40020, Tucson AZ 85717-0020. Five systems were installed in shelters at SM-ALC/DSTD, McClellan AFB CA 95652 and one system was installed in a shelter at HQ AFLC/DSTZ, Air Force Packaging Evaluation Agency (AFPEA), Wright-Patterson AFB OH 45433-5999.

The interior of the walls and roof of shelters 1, 2, 3, and 4 at SM-ALC/DSTD are foam and beam construction while shelter number 5 is constructed of paper honeycomb materials. The interior of the shelter at HQ AFLC/DSTZ is not insulated and the walls and roof are constructed of sheet metal.

Test Outline and Test Equipment

Equipment used to monitor the interior relative humidity (RH) and temperature (T) of the shelters during the field service test is as follows:

a. Probes for Humidity and Temperature Measurement
   Vaisala, Model HMP 23 UT
   (T = -20 degree C to +80 degree C/-4 degree F to +176 degree F)

b. Transmitters
   Vaisala, Model HMT-13B
   (T = -20 degree C to +80 degree C and RH 0 to 100 percent) with 4-20mA output signal for both RH and T.

c. Data Logger, Precision Digital
   Model No. 1045-FTM-MA-N-N
   Serial No. 208666

The shelter tightness test for air and water leakage was conducted in accordance with the methods in Appendix C, and performed on the S/T/Vs prior to installation of the FBSDH system (see Figures 7, 8, and 9). At this time, an extensive sealing operation was necessary with a polysulfide compound to eliminate the excessive air leakage. No requirement for the pressure/vacuum decay rate had been established at this time. Equipment used for this test was fabricated by AFPEA personnel in accordance with Figure 7 and was forwarded to SM-ALC/DSTD for their use in the preparation of the shelters for the field service tests.

After the shelter tightness tests were completed, a draw-down test was performed to dehumidify the interior atmosphere of the shelter(s). To lower the RH in these shelters, draw-down cartridges from the FBSDH system were installed to expose the silica gel (desiccant) to the shelter environment. In the

draw-down configuration (Figures 1, 5, and Appendix D), approximately 84 percent of surface area of the silica gel is exposed to the internal S/T/V environment, promoting the absorption of excessive moisture from the shelter interior into the silica gel.

Upon completion of the draw-down phase, the draw-down cartridges were removed and service-phase cartridges were placed into the housing to start the field service tests (Appendix E).

The remote humidity indicator (Figures 1, 10, and 11) is used to display the percentage of interior humidity in the S/T/V and should be observed at frequent intervals.

Layout of the shelter positions in the field test operations are shown in Figures 12 and 13 at SM-ALC/DSTD, McClellan AFB CA and HQ AFLC/DSTZ, Wright-Patterson AFB OH, respectively.

Table I outlines the interim reporting for the data obtained from the field service testing.

Test Procedures and Results

Inspection

Six systems were shipped from the contractor AGM Container Control, Inc., to SM-ALC/DSTD. Visual inspection of the exterior and interior surfaces, markings, hardware, strapping, and seals. Any manufacturing imperfections were noted by engineering personnel from SM-ALC/DSTD.

Results: Results of the visual inspection was satisfactory. Workmanship on the systems was classified as excellent.

S/T/V Tightness Test

The S/T/V tightness test was conducted in accordance with methods in Appendix C.

Results: Results of the pressure/vacuum tests are annotated in Table II and indicate that 2.0" Water Pressure (WP) held for approximately 30 minutes or less in each of the shelters, with the exception of shelter No. 1 at SM-ALC/DSTD. These results conclude that the shelters were not very air tight (excluding No. 1 at SM-ALC/DSTD). All shelters required an extensive sealing operation to establish the values in Table II and were considered satisfactory to initiate further testing. A pressure/vacuum decay rate had not been established; therefore, the data was retained to determine the decay rate criteria for the S/T/Vs.

Draw-Down Procedure

The draw-down procedure to pre-dry the shelters was conducted in accordance with the methods in Appendix D.

Results: Results of the draw-down are annotated in Table III. The shelters at SM-ALC/DSTD were below 30 percent RH for the draw-down phase and were put into their service mode immediately. Also, more than 40 hours were required for the draw-down period. The draw-down phase at HQ AFLC/DSTZ reached 10.4 percent RH, but this figure may be erroneous because of problems with the recording equipment. However, since this is the only RH value available on the shelter interior, after 4 days in the draw-down phase, it was considered satisfactory and FBSDH system was put into its service mode.

Field Service Test

The field service test was conducted in accordance with methods in Appendix E.

Results: The field service test results at SM-ALC/DSTD are displayed in Figures 14-26 and are as follows:

Shelter No. 1: From Table III, the draw-down phase obtained a minimum RH reading of 28.8 percent. From the follow-on data, Figure 14, the interior RH continued to increase as the field service test was continued. No effort was made, however, to restart the field service test since the data was required for evaluation of the FBSDH System. Figures 14 and 15 indicate that the interior maximum RH for each day throughout the field test remained above the 40 percent level. When the draw-down phase was initiated, little temperature cycling occurred (see Figure 16) under high RH environmental conditions (see Figure 17). Therefore, it has been determined that these conditions contributed to the FBSDH system's inability to maintain the internal maximum RH of 40 percent or less. In addition, it has been determined that moisture may have been trapped in the interior walls of the shelter. The sealing operation on the outer surface only allowed the moisture to migrate into the shelter interior and resulted in the high RH readings (see Figures 14 and 15).

The field service test was discontinued after 21 Jan 86 because the silica gel reached saturation and could not reactivate itself. The cartridges were removed and weighed. The cartridges absorbed 13.65 pounds of moisture and lost their effectiveness. Subsequently, the FBSDH system was removed from the shelter and sent to HQ AFLC/DSTZ, Wright-Patterson AFB OH. Visual inspection of the shelter revealed broken exterior sealed areas. This probably resulted from external weather conditions, such as the hot sun and rain.

Shelter No. 2: The draw-down phase, Table III, obtained a minimum RH reading of 11.9 percent and was considered satisfactory to start the service phase. The data from Figure 18 displays the interior maximum RH for 1985 below the 40 percent level only after the draw-down phase and throughout the month of Aug. This indicates that the draw-down phase did reduce the interior RH and that moisture migrated from the interior of the walls and was absorbed by the FBSDH system. This resulted in the higher internal RH readings for the first 3 months of 1985 (see Figure 18). However, from Apr-Aug 85 greater temperature cycling occurred, promoting the FBSDH system to reactivate itself and dissipate the absorbed moisture into the external environment. This was evident in the below 40 percent readings throughout Aug (see Figure 18, Julian date 213-244). From Sep 85 to May 86, the external temperature difference for each day decreased (see Figure 16, Julian dates 244-365 and Figure 19, Julian dates 1-121), which indicates less breathing. This caused the internal RH to increase (see Figure 18, Julian dates 244-365 and Figure 20, Julian dates 1-121). Visual examination of the shelter exterior did not reveal any deterioration to the sealed areas.

On 14 May 86, the cartridges were removed and weighed. The FBSDH system had absorbed 13.75 pounds of moisture. The unit had reached saturation and could not reactivate itself. Inspection of the shelter interior revealed condensed moisture on the walls. The shelter was aired out for two weeks and the cartridges were reinstalled on 31 May 86, to determine whether the FBSDH system could reactivate itself during the summer months. After reinstalling the cartridges into the shelter, the internal maximum RH increased to approximately 70 percent. This level was maintained from Jun-Sep 86 (see Figure 20, Julian dates 152-244). In Sep 86, the internal maximum RH increased to approximately 80 percent (see Figure, Julian date 244). This level of humidity maintained itself in the 70-80 percent range until 31 Oct 86, when the field test was concluded. During Sep-Oct 86, the external temperature cycling decreased (see Figure 19, Julian dates 244-304). It has been determined that the lack of temperature cycling contributed to the high internal maximum RH.

On 4 Nov 86, pressure and vacuum test were conducted with the following results; 1.0 minutes and 1.3 minutes, respectively. In addition, each cartridge was weighed with a total weight gain of 11.3 pounds of moisture. The shelter interior did not reveal the presence of condensation. The FBSDH system was then removed, packaged, and returned to HQ AFLC/DSTZ.

Shelter No. 3: The draw-down phase, Table III, obtained minimum RH readings of 13.5 percent and was considered satisfactory to initiate the service phase. Figure 21 displays the draw-down phase, 5-13 Feb 85, reduced the internal maximum RH to 22.3

percent. In the service phase, the maximum RH gradually increased to the 35-45 percent level and maintained that level until the end of Nov 85 (see Figure 21, Julian dates 325-335). At the end of November, the internal maximum RH decreased to 30 percent. At the beginning of December, the maximum internal RH increased to approximately 38 percent due mainly to high external RH conditions caused from rain. From the end of Dec 85 - mid-Feb 86 the internal maximum RH remained below 40 percent (see Figure 22). From Feb-May 86, the internal RH rapidly increased (see Figure 22, Julian dates 40-134). It appeared that the FBSDH system was saturated and unable to rejuvenate itself.

On 14 May 86, the cartridges were removed and weighed. The three cartridges in total absorbed 12.10 pounds of moisture. The interior was observed and condensation was evident on the shelter walls and floor. The shelter was aired out for two weeks, then the cartridges were reinstalled on 31 May 86. Shortly after the cartridges were reinstalled, the internal maximum RH increased to approximately 90 percent and maintained that level through 31 Oct 86. The performance of the FBSDH system throughout 1985 was satisfactory. However, in 1986 the FBSDH system performed very poorly, especially after February. During Feb 86, Sacramento experienced rain and may have contributed to the high internal maximum RH readings. The saturation appeared to be so severe that the FBSDH system could not reactivate itself, even during the summer months.

On 4 Nov 86, pressure and vacuum tests were conducted with the result of 1.5 minutes and 3.5 minutes, respectively. Additionally, each cartridge was weighed, with a total weight gain of 14.8 pounds of moisture. Some condensation was present on the interior of the shelter. The FBSDH system was then removed, packaged, and shipped to HQ AFLC/DSTZ.

Shelter No. 4: The draw-down phase, Table III, obtained a minimum RH of 20.7 percent and was considered satisfactory to initiate the service phase. Figure 23 displays the draw-down phase, 15-17 Jan 85, reduced the internal maximum RH to 33 percent. The internal maximum RH gradually increased to the 55-60 percent level until mid-Jun 85 and remained at that level until the end of Nov 85. It had been determined that moisture migrated from the interior of the shelter walls and was absorbed by the FBSDH system. This resulted in the 55-60 percent RH level from Jun-Nov 85. At the beginning of December, the internal maximum RH decreased gradually over a two week period to approximately 45 percent, then increased to approximately 52 percent (see Figure 23). This increase in internal RH corresponds to an increase in the environmental RH and rainy conditions (see Figure 17). Throughout 1986, the internal maximum RH gradually increased from 42 percent in January to 72 percent in August. The internal maximum RH maintained that level until the end of August and

gradually decreased to 65 percent in October. It has been determined that the cartridges gradually became saturated during the field test. The FBSDH system was not able to reactivate itself, which resulted in the internal maximum RH readings in the range of 40-60 percent throughout most of the field test (see Figures 23 and 24).

On 4 Nov 86, pressure and vacuum tests were conducted with the following results of 9.5 minutes and 7.0 minutes, respectively. Additionally, each cartridge was weighed, with a total weight gain of 10.0 pounds. Moisture was not present on the shelter interior. The FBSDH system was then removed, packaged, and shipped to HQ AFLC/DSTZ.

Shelter No. 5: The draw-down phase, Table III, obtained a minimum internal RH of 19.6 percent and was considered satisfactory to start the service phase. Figure 25 displays the draw-down phase had reduced the internal maximum RH to 39 percent. In the service phase, the internal maximum RH followed the external maximum RH trends (see Figure 17) throughout 1985 except for November and December. This correspondence between internal and external maximum RH was anticipated because of the poor shelter condition and the inability of the shelter to hold pressure or a vacuum (see Table II). It appears from Figures 25 and 26 (Julian dates 315-365 and 1-40, respectively) that the FBSDH system began to reactivate itself during Nov 85 - Feb 86. For the remainder of 1986, the internal maximum RH gradually increase to the the 50-60 percent range and maintained that level (see Figure 26). It appears from the data that the cartridges had absorbed moisture, but were not saturated. The FBSDH system in Shelter No. 5 had the best results in the field test. but the internal RH did exceed the 40 percent level.

On 4 Nov 86, pressure and vacuum tests were conducted and the results were 1.0 minutes and 1.3 minutes, respectively. In addition, the cartridges were removed and weighed. The total weight gain of the cartridges was 12.10 pounds of moisture. The interior of the shelter revealed that condensation was not present. The FBSDH system was then removed, packaged, and returned to HQ AFLC/DSTZ.

Results of the field service test, Figures 27-31, at HQ AFLC/DSTZ are as follows:

Shelter No. 1: The draw-down phase, Table III, obtained a minimum internal RH of 2.9 percent, but this value may be erroneous due to problems with the recording equipment. However, since this is the only RH value available on the shelter interior, it was considered satisfactory and the FBSDH system was put into its service operation. Figure 27 displays the draw-down phase, 8-13 Aug 85, obtained a internal maximum RH of 38.2 percent. In 1985,

the internal maximum RH remained below the 60 percent level except on 12-15 Sep, 20-21 Nov, and 2-3 Dec. These results are favorable, since the internal humidity was kept below the level of the external conditions (see Figure 28). The internal maximum RH for 1986 gradually rose from approximately 60 percent in January to approximately 93 percent in mid-February (see Figure 29, Julian dates 1-40). During this period, the external maximum RH also was increasing (see Figure 30). As 1986 continued, the temperature cycling increased (see Figure 30) and the FBSDH system began to slightly reactivate itself. This was evident in the decreasing trend in the internal maximum RH from Feb-Aug 86 (see Figure 29, Julian dates 40-243). The high internal maximum RH readings appeared to correspond to the external RH, mainly due from the uninsulated walls and roof of the shelter.

On 4 Sep 86, pressure and vacuum tests were conducted. The shelter could not maintain a pressure or vacuum for any length of time. The cartridges were removed and weighed, with a total weight gain of 7.91 pounds. The interior of the shelter revealed no condensation.

Cost:

Cost studies for production quantities have been completed and are summarized as follows:

MULTIPLE UNIT PRICE ESTIMATE

NUMBER OF FBSDH SYSTEMS	PRICE PER FBSDH SYSTEM
10 - 25	$3400
26 - 50	$2400
51 - 100	$1700
101 - 500	$1300
501 - 1000	$1000
1000 or more	$950

NOTES:

1. A FBSDH system consists of one (1) housing, one (1) remote indicator tube, two (2) relative humidity indicators and three (3) cartridges filled with silica gel.

2. Prices include preservation packaging for the cartridges in accordance with MIL-P-116, Submethod 1A-14 and commercial packing for the complete system.

3. Prices are for planning purposes in 1984 dollars.

Conclusion:

Results of the field service test, 15 Jan 85 - 31 Oct 86, did not verify the design of the prototype FBSDH system by maintaining a 40 percent or less RH in the interior of the S/T/Vs. S/T/Vs used in the field test operation at SM-ALC/DSTD were not new and required an extensive sealing operation on the doors, fasteners, gaskets and any other openings to prevent air leakage. The shelter at AFPEA was not insulated and had a wooden floor; therefore, the floor required the application of a water-barrier laminate. Consequently, the field test operation was initiated with less than ideal S/T/Vs and with best effort refurbishing conditions.

All shelters acquired the 40 percent or less RH requirement for the draw-down phase, but when the service phase began the RH gradually increased above the 40 percent level. During 1985, three of the five shelters at SM-ALC/DSTD (No.s 3, 4 and 5) had coinciding internal maximum RH, but at slightly different humidity levels. Also, four of the five shelters at SM-ALC/DSTD (No.s 2, 3, 4 and 5) obtained similar internal maximum RH trends during the summer months (May-Aug 85). During 1986, all shelters had their internal maximum RH remain above the 40 percent level, except shelters 3, 4, and 5 from 1 Jan-15 Feb. Shelter No. 1 at SM-ALC/DSTD remained consistently above the 40 percent level in its service mode. The shelter at AFPEA also went above the 40 percent level during its service phase. The internal maximum Rh remained constantly above 40 percent throughout the field test. The various RH trends were created by the different S/T/V conditions. It has also been determined that moisture in the interior of the walls of the shelters at SM-ALC/DSTD migrated into the shelter interior and was absorbed by the FBSDH system at different rates and resulted in greater than 40 percent RH throughout the field test.

Further examination of the data indicate more emphasis is required in the following areas:

1. A method to detect localized water-intrusion through the external surface of the shelter structured panel (from TO 35E4-1-162, paragraph 4-29) will be conducted prior to the pressure/vacuum test to help determine the condition of the S/T/V:

a. DETECTION OF LOCALIZED WATER-INTRUDED AREAS. If, during periodic inspection, delamination is suspected on an external surface of the shelter structural panel, the panel must be further examined to determine possible causes before repair is made. The most reliable and efficient method of detecting delaminations and/or voids is to use the coin-tap method. The extent of the delamination and/or void must be marked with chalk or a marking pen. Before repair, reinspect the area within the

marked outline for any possible holes, riveted doublers, or bolted fittings which either lack sealant or where sealant has cracked or peeled away. If sealant is defective or missing, it is almost certain that water has intruded inside the panel and damaged the core material.

Refer to the appropriate procedure in TO 35E4-1-162 for the type of repair that is required. (Appendices C, The S/T/V Tightness Test, and D, The Draw-Down Procedure, must be changed to reflect this procedure.)

2. The S/T/V housing the FBSDH system must have a pressure/vacuum decay rate that will hold 2.0" WP (0.072 psi) for 60 minutes (Appendix B, The Prototype Unit, paragraph 1.4 and Appendix C, The S/T/V Tightness Test, paragraphs 3.6 and 4.2, must be changed to indicate this decay rate).

3. The draw-down RH of 40 percent or less must be held for a 24 hour period to ensure that the maximum RH level for that day is actually below the 40 percent or less level. (Appendices D, The Draw-Down Procedure, and E, The Preparation and Maintenance of the FBSDH System, paragraph 2.1, must be changed to indicate this.)

4. The service phase must be initiated after a proper draw-down phase (see #2), between 1200 and 1600 hours, when the external RH is approaching its lowest level of the day. (Appendix E, The Preparation and Maintenance of the FBSDH System, paragraph 2.1, must be changed to reflect this.)

5. Value engineer the FBSDH System with the following:

a. Desiccant cartridges:

(1) Design seals into housing.

(2) Change material to polymer or polymer/metal.

(3) Eliminate nylon bag.

(4) Eliminate guides and stops.

b. Housing:

(1) Change door design to use hinges.

(2) Design housing internal symmetrically.

(3) Design extruded seal that can be used as a cartridge and door gasket.

(4) Change material to coated steel.

c. Remote humidity indicator tube:

(1) Eliminate machined tube and use flat plate.

(2) Change material to polymer.

The test data displays that the FBSDH system could not maintain 40 percent or less RH and control the internal environment of the S/T/Vs; therefore, the FBSDH system should not be installed into S/T/Vs. The FBSDH system may have possible application with equipment or containers that have the minimum requirement of holding 2.0" WP (0.072 psi) for 60 minutes.

Recommendations:

1. If S/T/Vs were modified to meet pressure requirements than an operational test and evaluation of the FBSDH system should be attempted.

2. Upon successful completion of the FBSDH system in air tight equipment or containers, suggested design changes and/or improvements should be added to reduce the cost of the FBSDH system (see point 5 of the Conclusion).

APPENDIX A

INSTALLATION OF A FREE BREATHER STATIC DEHUMIDIFICATION SYSTEM AND HUMIDITY INDICATORS IN A SHELTER/TRAILER/VAN

1.0 INTRODUCTION

1.1 Two humidity indicators are used with the installation of the FBSDH system. One humidity indicator is installed in the cover of the FBSDH system and the other is installed through the wall of the S/T/V in a location away from the FBSDH system. The humidity indicator installed in the cover of the FBSDH system is a guide to the condition of the desiccant in the FBSDH system. The humidity indicator located away from the FBSDH system is a guide to the RH in the S/T/V.

1.2 The humidity indicators contain a color change disc which changes from blue to lavender to pink as the RH increases and turns back to blue as the RH decreases.

1.3 Each color change disc is divided into four segments, these segments correspond to 30, 40, 50, and 60 percent RH respectively. For example, if the 40 percent segment of the disc is lavender or pink, the humidity indicator is indicating a RH of over 40 percent. But it is also indicating that the RH is less than 50 percent.

1.4 The FBSDH system is a self-contained modular unit. The FBSDH system is designed to be easily mounted and/or removed from the exterior wall/door of a S/T/V.

1.5 The air inlet tube to the FBSDH system is designed to protect against the ingress of blowing snow, rain, dirt, insects, animals, birds and/or other foreign materials.

1.6 Each FBSDH system module was designed to hold enough units of desiccant for a service life of two years and should maintain the RH of 40 percent or less in a S/T/V that is 8'x8'x10' when in accordance with MIL-STD-210B, Table V.

2.0 INSTALLATION OF FBSDH SYSTEM

2.1 The FBSDH system is to be installed in the main structure of the S/T/V.

2.2 The separate humidity indicator is to be installed in the structure of the S/T/V as described in paragraph 2.7.

2.3 Select a location in the structure of the S/T/V for installation of the FBSDH system. Check carefully for clearance around

the FBSDH system and particularly the clearance for protrusion of the FBSDH system into the S/T/V. In the draw-down configuration a clearance of 14 inches is required around the cartridges. The FBSDH system cover must be accessible from the exterior S/T/V for servicing while the S/T/V is in storage. A door of the S/T/V is the preferred location.

2.4 Using the template shown in Figure 32, cut the required opening for the installation. If the cut is in honeycomb or sandwich construction, seal the filler between the inside and outside sheathing with a polysulfide compound (conforming to MIL-S-81733, Type I-2, solvent) in a well ventilated area. Refer to TO 35E4-1-162, paragraphs 4-15, 4-16 and 4-17 for further instructions on application procedures.

2.5 Apply a thin coating of sealer (polysulfide compound) to the inside surface of the mounting flange on the FBSDH system housing, and attach the FBSDH housing to the S/T/V using rivets or drive screws. Remove excess sealer.

2.6 Check the installed FBSDH system for clearance and room for protrusion of the cartridges into the S/T/V.

2.7 Select a location for the separate humidity indicator tube. This location should be remote from the FBSDH system main unit. The opposite end of the S/T/V is the preferred location; however, the separate humidity indicator may be installed at any location more than five feet away from the FBSDH and about four feet above the bottom of the S/T/V. The separate humidity indicator should be installed in a location that can be viewed when the S/T/V is in storage.

2.8 Using the template shown in Figure 11, cut an opening for the separate humidity indicator tube. Seal the opening cut and the flange of the holder as described in paragraphs 2.4 and 2.5.

2.9 Thoroughly clean the inside of the S/T/V. Wipe all surfaces clean and free of visible moisture. Close and secure all accesses, doors and openings in the S/T/V. Install a humidity indicator in the hole provided in the upper right hand corner of the FBSDH system cover and install the FBSDH system cover. Install a humidity indicator in the holder installed in paragraph 2.7 and 2.8.

APPENDIX B

FREE BREATHING STATIC DEHUMIDIFICATION SYSTEM (PROTOTYPE UNIT)

1.0 INTRODUCTION

1.1 The FBSDH system is intended to provide a dry storage environment for materiel inside of S/T/V by maintaining a relative humidity of 40 percent or less during the diurnal breathing cycles.

1.2 Changes in the atmospheric temperature will create changes in the air flow through the FBSDH system. As the interior temperature of the S/T/V will increase, the interior pressure will tend to increase causing the air in the S/T/V to flow out. As the interior temperature in the S/T/V decreases, the interior pressure decreases tending to cause air to flow in. These daily changes in atmospheric conditions is called the diurnal cycle. In the inflowing phase of the diurnal cycle, the air is usually humid. This inflow of humid air raises the RH in the S/T/V and causes deterioration of materiel inside the S/T/V. The FBSDH system is designed and installed so that the flow of air into and out of the S/T/V will flow through the FBSDH system thus drying the air and preventing the increase in RH in the S/T/V from exceeding 40 percent.

1.3 The FBSDH system is used initially for reducing the RH below 40 percent in the S/T/V (called the draw-down phase) and also for maintaining the RH in the S/T/V below 40 percent (called the service phase).

1.4 The FBSDH system is intended only for installation in S/T/V that are designed and fabricated to have an established pressure/vacuum decay rate that will be determined from this field test operation.

2.0 DESCRIPTION OF FBSDH SYSTEM

2.1 A schematic diagram of the FBSDH system is shown in Figure 1. It consists of a major unit to be mounted in a wall or door of a S/T/V and a separate humidity indicator to be mounted remotely from the major unit to monitor the atmosphere inside of the S/T/V. The major unit contains three (3) replaceable desiccant cartridges.

2.2 The major unit of the FBSDH System is a housing 8" high x 15-1/2" wide x 9" deep and weighs 14 pounds. The housing construction includes a flange. The flange contains 28 1/4" diameter holes to be used for mounting the FBSDH system on the S/T/V. Inside of the housing is a baffle system which contains

chambers for installation of desiccant cartridges. The baffle system includes a breathing tube and passage to direct the flow of breathing air through the desiccant cartridges. The major unit is provided with a cover which is attached to the housing with 22 captive screw type fasteners. In the upper right hand corner of the cover is a Humidity Indicator used to monitor the condition of the desiccant charge. An inlet elbow is attached to the lower right hand corner of the cover. A rubber plug for the inlet opening is attached to the cover by a chain.

2.3 Three cartridges of silica gel are provided with each FBSDH system. Each cartridge contains approximately 17 pounds of silica gel MIL-D-3716, Type II, grade H. The total of 51 pounds of silica gel is equivalent to approximately 600 units of desiccant. The top, bottom, and three sides of the cartridges are of perforated aluminum alloy. The fourth side or edge of the cartridge is solid (unperforated). The rubber strip in the cartridge construction is to seal the cartridge to the baffle assembly when the cartridges are installed in the housing. Figure 4 shows a cartridge.

2.4 The cartridges are designed to be installed with the unperforated surface facing outside the S/T/V for the draw-down phase (Figure 5). In this configuration a large area of desiccant is exposed to the humid air inside the S/T/V. For the service phase the cartridges are installed with the unperforated surface facing inside the S/T/V. In this configuration the breathing air flows through the cartridges.

2.5 A charge of silica gel in the FBSDH system is used to adsorb moisture from the inbreathing humid air. The outbreathing air from the interior of the S/T/V flows through the charge of silica gel in a path that it will remove some of the absorbed moisture from the silica gel (Figure 6), and dissipate it into the external environment.

2.6 Pressure drop of the air flow through the system is 0.01 inches of water. (It should be noted that the lower the pressure drop through the system, the more likely it is that breathing air will flow through the system, rather than leaking into the S/T/V through some other path).

APPENDIX C

TESTING SHELTER/TRAILER/VAN FOR TIGHTNESS PRIOR TO USE OF THE FREE BREATHER STATIC DEHUMIDIFICATION SYSTEM

1.0 INTRODUCTION

1.1 It is important that the structure of an S/T/V, in which a FBSDH system is installed, be air tight. Leakage of humid air and water into the S/T/V must be eliminated for the breathing cycles to pass through the FBSDH system.

1.2 Since our concern is the leakage of air, a method of testing using air is required. A pressure/vacuum decay rate has not been established; therefore, it is essential to retain all data to determine the decay rate criteria.

1.3 The first step in the air tightness test is to stabilize the S/T/V for 12 hours in an environment that is not in direct sunlight. The environment stabilizing the S/T/V must also not have changed more than 10 degrees F during this stabilization time.

1.4 The second step in the air tightness test is a thorough visual internal and external check of the condition of the S/T/V. Warped doors, small openings, missing fasteners and deteriorated gaskets and seals should be repaired during this check.

1.5 Since the FBSDH system will be placed in service as soon as the tightness test is completed, the interior of the S/T/V should be clean, dry and ready for installation. Equipment in the S/T/V should be properly secured. Required documentation such as a T.O., shipping instruction, etc., for the equipment in the S/T/V should be checked.

1.6 The method of testing shall consist of applying low pressure air to the inside of the S/T/V and checking the outside of the S/T/V for leakage using a soap bubble test. When all leaks have been corrected, a vacuum shall be applied to the S/T/V. Finally, the differential pressure, between the inside and the outside of the S/T/V, shall be measured and recorded along with the time required to hold the 2.0" WP.

1.7 The pressure test is used to apply a pressure to the inside of the S/T/V so that leaks can be found using the soap bubble method. The vacuum test is used as a final test.

2.0 TEST EQUIPMENT

2.1 The equipment required for the test is shown on Figure 7. It consists of a Vac/Blower a test manifold, a manometer and hoses to connect the test equipment to the FBSDH and to the Vac/Blower.

2.2 The Vac/Blower supplies the positive pressure for the pressure test and the vacuum for the vacuum test.

2.3 The manometer is used to measure the differential pressure and the rate at which the differential pressure decays.

2.4 Thin walled flexible rubber hose is used to connect the Vac/Blower to the manifold and the manifold to the inlet of the FBSDH. Hose clamps will be required on the ends of this hose to prevent leakage.

3.0 PRESSURE TEST

3.1 Connect the test manifold to the FBSDH, as shown on Figure 9. Close Valve "A." Connect the Vac/Blower pressure side to the manifold.

3.2 Start the Vac/Blower.

3.3 Slowly open Valve "A" while observing the pressure differential on the manometer. If the manometer is less than 2.0" WP restrict the opening to obtain 2.0" WP.

3.4 Using a soap solution check all potential sources of leakage in the S/T/V. Sources of leakage would be joints, penetrations, door gaskets and similar places. During this test, check the hose connection between the manifold and the FBSDH system. As leaks are found they should be corrected or marked for correction.

3.5 Correct leaks by use of approved sealing compounds, caulking materials and tape. Recommended sealing compound is a polysulfide compound, PR-468, which is in accordance with MIL-S-81732, type I-2 (solvent). This should be applied in well ventilated area. Refer to TO 35E4-1-162, paragraphs 4-15, 4-16 and 4-17 for instructions on application procedures.

3.6 Close Valve "A". Observe the decay of pressure on the manometer. The pressure differential should slowly decay. Record the time required to hold 2.0" WP.

4.0 VACUUM TEST

4.1 Connect the Vac/Blower for suction on the test manifold. Close Valve "A". Start the Vac/Blower.

4.2 Slowly open Valve "A" while observing the differential

pressure reading on the manifold. Record the time to hold 2.0" WP.

4.3 Repeat the pressure test and the vacuum test as necessary to ensure the S/T/V does not leak.

5.0 DATA TO BE RECORDED

5.1 A certification sheet showing that the test has been completed should be kept on file.

5.2 A record of the repairs made and the condition of the S/T/V should be kept on file.

6.0 RETESTING

6.1 The pressure and vacuum test should be repeated in the event of damage to the S/T/V, noticeable deterioration of the seals or structure of the S/T/V or modifications to the S/T/V.

6.2 The pressure and vacuum tests should be repeated in the event the relative humidity indicators installed with the FBSDH show that the desiccant charge is exhausted in a shorter time than expected.

NOTE:

1. Immediately upon satisfactory completion of this test the FBSDH system should be put in service in the draw-down mode.

APPENDIX D

DRAW-DOWN PROCEDURE IN PREPARATION OF SHELTERS/TRAILERS/VANS FOR FIELD SERVICE TESTS

1.0 INTRODUCTION

1.1 The S/T/V must be pre-dried to 40 percent or less RH and must not contain visible moisture in the form of condensation or puddles. Further the pre-drying or draw-down operation must ensure that moisture absorbed on the surfaces of the interior of the S/T/V, and its contents, is removed.

2.0 ACTIVATION OF FBSDH SYSTEM FOR DRAW DOWN

2.1 Prepare to remove the cover of the FBSDH system and insert the desiccant cartridges. Three cartridges will be installed. The operation of unpacking the cartridges, inserting them and reinstalling the FBSDH system cover should be accomplished in as short a time as possible to reduce exposure of the cartridges to humid air. Examine Figure 4 which shows the cartridge. Note the stops and guides on the top and bottom of the cartridges. Note also that one vertical face of the cartridge is unperforated.

2.2 Cartridges can most easily be inserted in the housing by tilting the top slightly outward, lifting the cartridge high enough so that the guides on the bottom of the cartridges can be placed on the lower horizontal baffle in the housing, then straightening the cartridge and pushing it at top and bottom into the housing chamber, cartridges are a snug fit in the chambers.

2.3 Procedure.

2.3.1. Remove the FBSDH cover, unpack three cartridges, note and record their serial number and weight and insert them in the housing.

2.3.2. Each cartridge should be inserted with its unperforated face out. The cartridges should be inserted about 7 inches into the chambers and firmly against the stops.

2.3.3. Reinstall the FBSDH system cover. Check to be sure that all of the captive fasteners are securely tightened. Do not install the rubber plug.

2.4 The draw down phase Figure 5 is now in operation and should take about 40 hours, according to MIL-P-116.

APPENDIX E

PREPARATION AND MAINTENANCE OF FREE BREATHING STATIC DEHUMIDIFICATION SYSTEMS FOR FIELD SERVICE TESTING

1.0 INTRODUCTION

1.1 The FBSDH System is intended to provide a dry storage environment for materiel inside of S/T/Vs by maintaining a RH of 40 percent or less during the diurnal breathing cycles.

1.2 The FBSDH System was designed for a service life of 2 years in an environment of -40 degree F (-40 degree C) to +155 degree F (+68 degree C) when installed in a S/T/V size of 8'x 8'x 10'. During this period no maintenance should be required.

2.0 ACTIVATION OF FBSDH SYSTEM FOR SERVICE

2.1 The draw down phase has been completed when the remote humidity indicator reads 40 percent or less. The FBSDH system service phase is ready to begin.

2.2 Prepare for replacement of the desiccant cartridges by ensuring that three sealed packages of desiccant cartridges are ready for installation.

2.3 Remove the cover by loosening the screw fasteners that hold the cover to the housing. Remove the desiccant cartridges that were used for draw down. Immediately install three new desiccant cartridges. The cartridges are to be installed with the perforated face out. When properly installed the cartridges will be flush with the outside of the housing (Figure 3). The cartridges are designed to be a snug fit in the baffle assembly chambers. The cartridge seal must be forced over the stops in the housing baffle assembly.

2.4 Close and secure the FBSDH system housing cover.

2.5 Do not discard the desiccant cartridges used for the draw down phase. They may be refilled or reactivated, refer to paragraph 4.0 for procedure.

3.0 MAINTENANCE OF FBSDH SYSTEM

3.1 At intervals of once a month, both humidity indicators should be observed. They should indicate 40 percent or less RH.

3.2 If the humidity indicator in the cover of the FBSDH system shows an RH of below 40 percent and the remote indicator shows an RH of more than 40 percent, the S/T/V is leaking. Determine the source of the leakage and make corrections. Retest the S/T/V as

described in Appendix C and repeat the draw down as described in Appendix D.

3.3 If the humidity indicator in the cover shows an RH of greater than or equal to 40 percent and the remote indicator shows an RH of 40 percent or less, the desiccant cartridges should be replaced. During this period, monitor the remote indicator twice daily. If the RH at the indicator does not exceed 40 percent, it is not necessary to repeat the draw-down phase. If the RH at the remote indicator exceeds 40 percent, the S/T/V is leaking. Determine the source of leakage and make corrections. Retest the S/T/V and repeat draw-down.

4.0 REACTIVATION OF THE FBSDH SYSTEM CARTRIDGES

4.1 Desiccant cartridges may be reactivated by placing them in a dry vented oven which has been heated to 260 degree F. Before activation the cartridge should be weighed and the weight recorded. The cartridge should remain in the oven for 48 hours. Remove the cartridge and record the weight. The weight of the reactivated cartridge assembly should be close to that marked on the cartridge name plate. If the weight of the cartridge and desiccant exceeds the weight marked on the cartridge label plate by more than 2 pounds, return the cartridge to the oven for another 48 hours. When the weight condition had been achieved, mark the weight on the proper line on the cartridge name plate. If the cartridge is not to be placed in service immediately, it should be packaged according to MIL-P-116, submethod 1A-14. Tag the package to indicate date of reactivation and weight.

4.2 Cartridges may be disassembled and desiccant reactivated. To disassemble a cartridge, remove the eight flat head machine screws holding the cartridge top to the sides of the cartridges. Note how the cartridge seal is assembled between the cartridge solid edge and the cartridge top. This seal must be reassembled in the same fashion. If any part of the cartridge seal is damaged, the cartridge should be returned to a repair base for repairs.

4.3 Open the nylon bag containing the desiccant and pour the desiccant into a clean container. Examine the nylon bag. If the bag is torn, it may be repaired by patching. Retain the nylon bag for reuse.

4.4 Weigh the desiccant and spread it on a clean flat metal pan. Place the pan in a dry, vented oven at a temperature of 260 degree F. The desiccant should be allowed to remain in the oven for 24 hours. Remove the pan and desiccant and weigh the desiccant. The weight of the desiccant should be close to that shown on the cartridge nameplate. If the weight exceeds the name plate weight by more than 2 pounds, the desiccant should be

returned to the oven for another 24 hours, or until the weight condition has been achieved.

4.5 Prepare the cartridge for refilling by inserting the nylon bag carefully into the aluminum cartridge canister. The bottom of the bag should be pushed to the bottom of the canister and the bag spread to the insides of the canister. Pour the reactivated desiccant carefully into the nylon bag. Close the top of the bag with staples or by sewing. Replace the top of the cartridge exercising caution to ensure that the top portion of the gasket seal is properly installed. Note the weight of the cartridge and mark the cartridge name plate accordingly. If the cartridge is not to be placed in service immediately, it should be packaged according to MIL-P-116, submethod 1A-14. Tag the package with the weight and date of recharging.

5.0 REFILLING OF DESICCANT CARTRIDGES WITH DESICCANT

5.1 Cartridge may be refilled with fresh desiccant. Remove the top of the cartridge in accordance with paragraph 4.2. Open the nylon bag and discard the desiccant. Note: The desiccant may be saved by reactivation as described in paragraph 4.4. Check the nylon bag as described in paragraph 4.3 and 4.5. Refill the cartridge with silica gel, MIL-D-3716 SPEC, Type II, Grade H. Replace the top, checking the gasket seal and mark the cartridge name plate as necessary. Package the cartridge, according to MIL-P-116, submethod 1A-14 if it is not to be put into service immediately.

6.0 TAKING FBSDH SYSTEM OUT OF SERVICE

6.1 The FBSDH system is taken out of service by installing the plug into the inlet elbow at the lower right hand corner of the FBSDH system cover. Desiccant cartridges may be removed or retained in the housing.

7.0 REMOVAL OF FBSDH SYSTEM

7.1 The FBSDH system may be removed from the S/T/V by unbolting the FBSDH system housing flange. The remote separate RH indicator tube may be removed by unbolting the flange from the S/T/V.

7.2 Blank the openings in the S/T/V with suitable metal plate, properly sealed.

TABLE I

INTERIM REPORTING

1. Type A: Telephonic Communication

Frequency: Once per week for four weeks

Contents: Review of performance of FBSDH during the previous seven days.

2. Type B: Written Report

Frequency: Once per month for duration of project

Content:

a. It should be noted that data was recorded each day, every hour within the 24-hour period, for each of the five shelters.

b. Exterior temperature and relative humidity readings correspond to 0400 and 1600 hours denoting the maximum environmental changes in the SM-ALC area according to data from the USAF weather station.

c. General weather conditions for each 7-day period.

d. This report will also include all pertinent information that the engineers of record regard as a significant contribution to the document of this field test.

3. As the project goes forward, reporting procedures will be adjusted as required.

TABLE II

PRESSURE/VACUUM TEST*

Shelter No.	Pressure	Vacuum	Date
SM-ALC/DSTD			
1**	120.0 Min	120.0 Min	8 Nov 84
2	16.0 Min	10.0 Min	23 Aug 84
2	1.0 Min	1.3 Min	4 Nov 86
3	10.0 Min	10.0 Min	11 Oct 84
3	1.5 Min	3.5 Min	4 Nov 86
4	30.0 Min	6.0 Min	26 Sep 84
4	9.5 Min	7.0 Min	4 Nov 86
5	2.0 Min	2.0 Min	30 Oct 84
5	1.0 Min	1.3 Min	4 Nov 86
HQ AFLC/DSTZ			
1	0.0 Min	0.0 Min	Aug 85
1	0.0 Min	0.0 Min	4 Sep 86

*Time is in minutes for pressure/vacuum decay from 2.0" WP to 0.0" WP. No pressure/vacuum decay rate was established when the field test operation was initiated; therefore, multiple trials were performed on each shelter during the sealing operations. When the best possible decay time was recorded on any given shelter, the sealing process was discontinued.

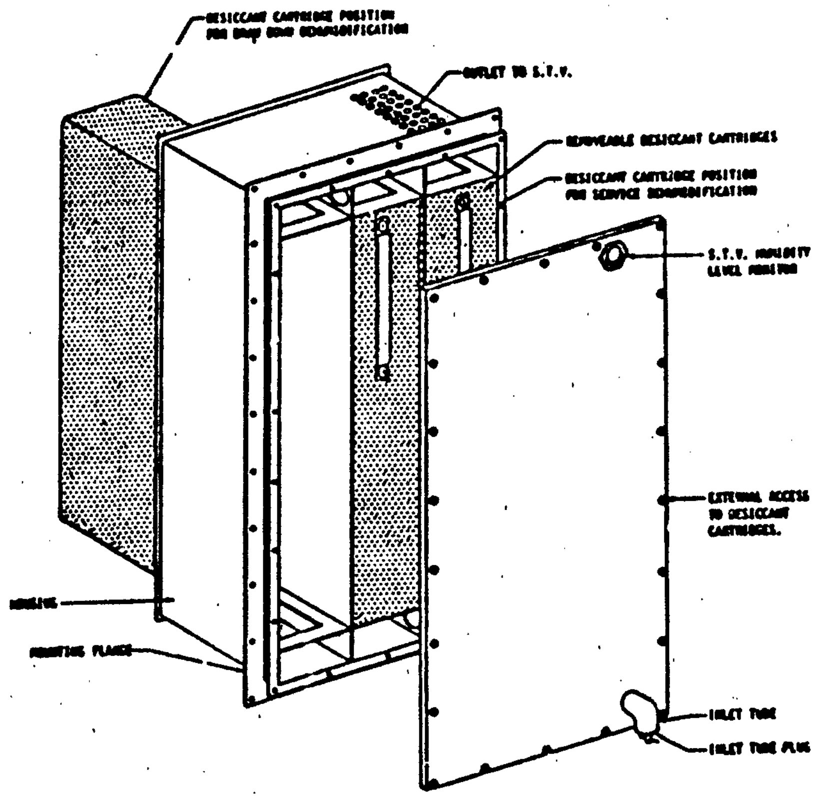
**FBSDH System was taken out of the shelter on 21 Jan 86. A final pressure/vacuum test was not conducted.

TABLE III

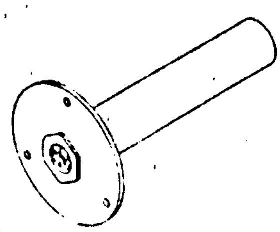
DRAW-DOWN DATA BEFORE START OF FIELD SERVICE TESTING

Shelter No. SM-ALC/DSTD	Shelter Interior Vol Cu Ft	System Orientation*	Draw-Down Date	Maximum Draw-Down Before Start of Field Serv Test: Interior R.H.%	Interior Temp F	Exterior R.H.%	Exterior Temp F	Date Field Service Test Made Operational
1	576 (8'x8'x9')	North	15-17 Jan 1985	28.8	55	93.0	46	17 Jan 1985
2	576 (8'x8'x9')	South	25-31 Jan 1985	11.9	51	38.0	60	31 Jan 1985
3	608 (8'x8'x9 1/2')	East	5-13 Feb 1985	13.5	53	85.0	53	13 Feb 1985
4	608 (8'x8'x9 1/2')	West	15-17 Jan 1985	20.7	58	93.0	46	17 Jan 1985
5	960 (8'x8'x15')	South	15-17 Jan 1985	19.6	56	93.0	46	17 Jan 1985
Shelter No. HQ AFLC/DSTZ								
1	512 (8'X8'X8')	North	9-13 Aug 1985	10.4	90	4.0	95	13 Aug 1985

* Figures 10 and 11 describe the shelter positions at SM-ALC/DSTD, McClellan AFB CA and HQ AFLC/DSTZ, Wright-Patterson AFB OH, respectively.



FREE BREATHING STATIC DEHUMIDIFICATION SYSTEM

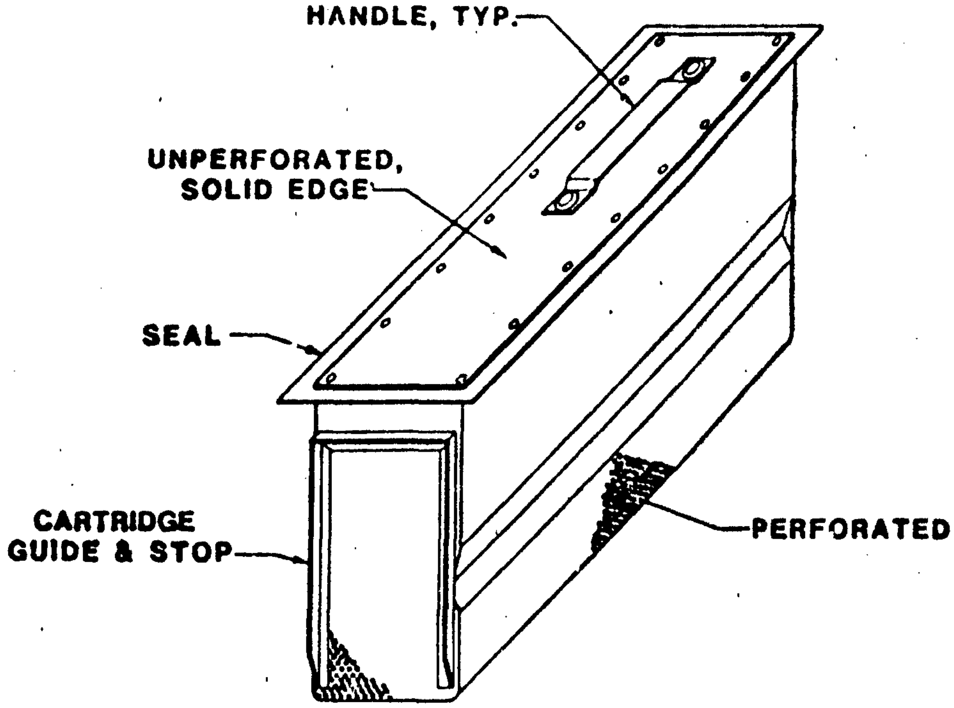


REMOTE HUMIDITY INDICATOR

FIGURE 1

Figure 2. Front View of FBSDH system.

Figure 3.
Back View of FBSDH system in Service Configuration.



FBSDH CARTRIDGE

FIGURE 4

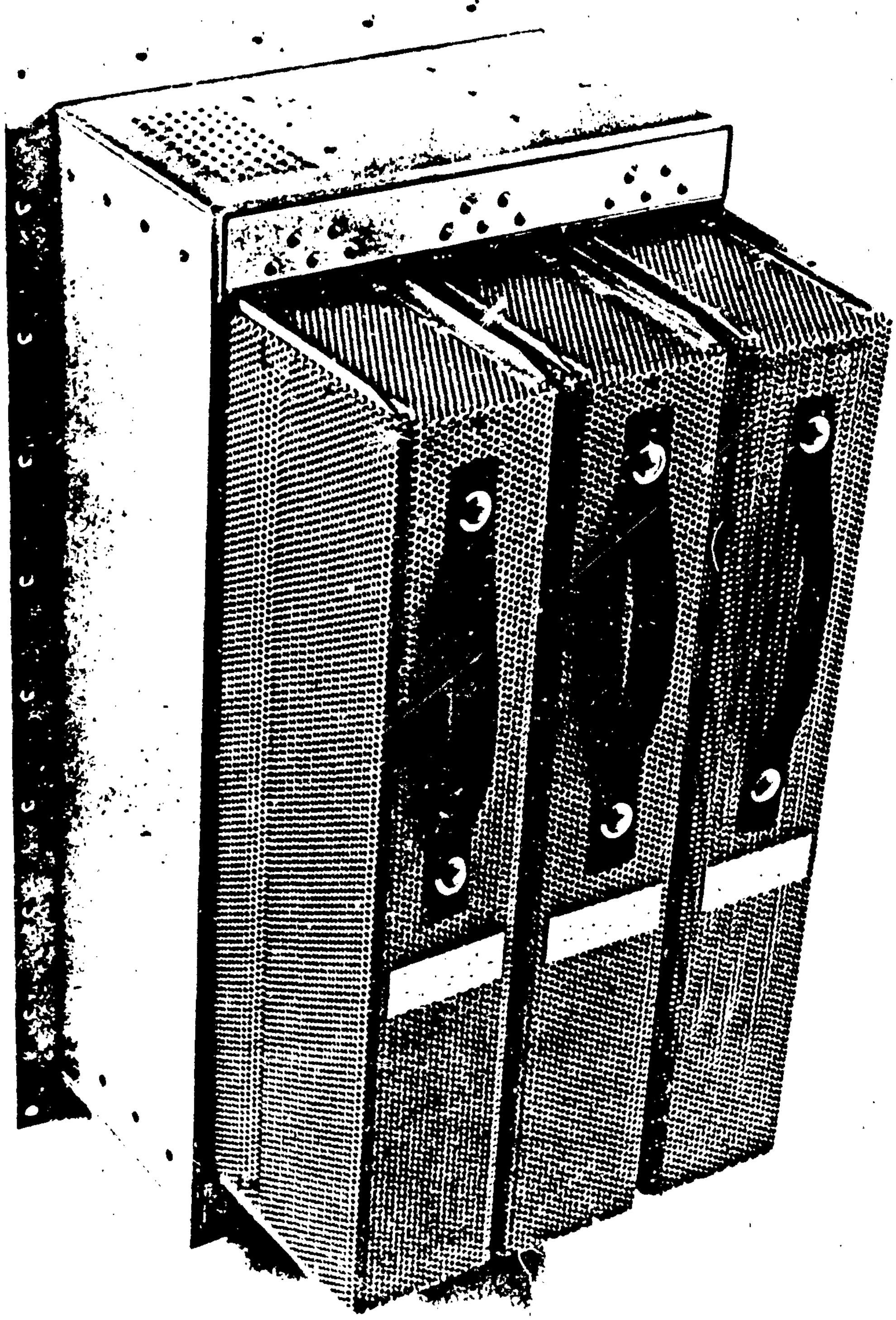
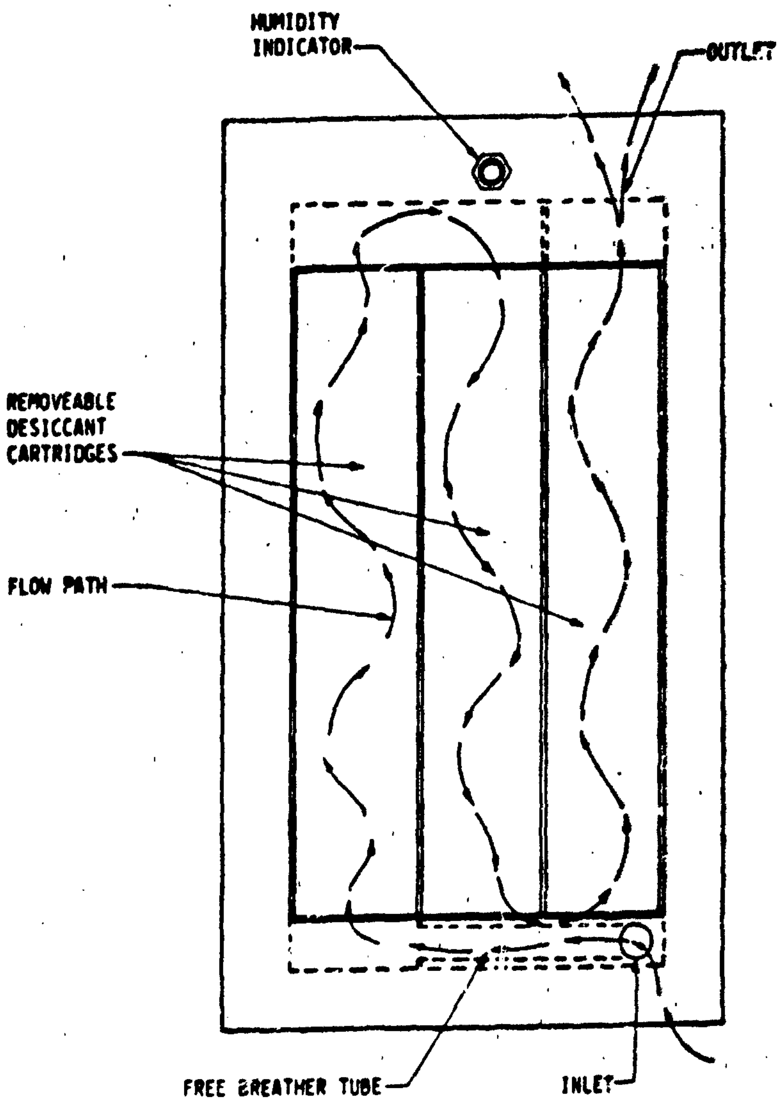
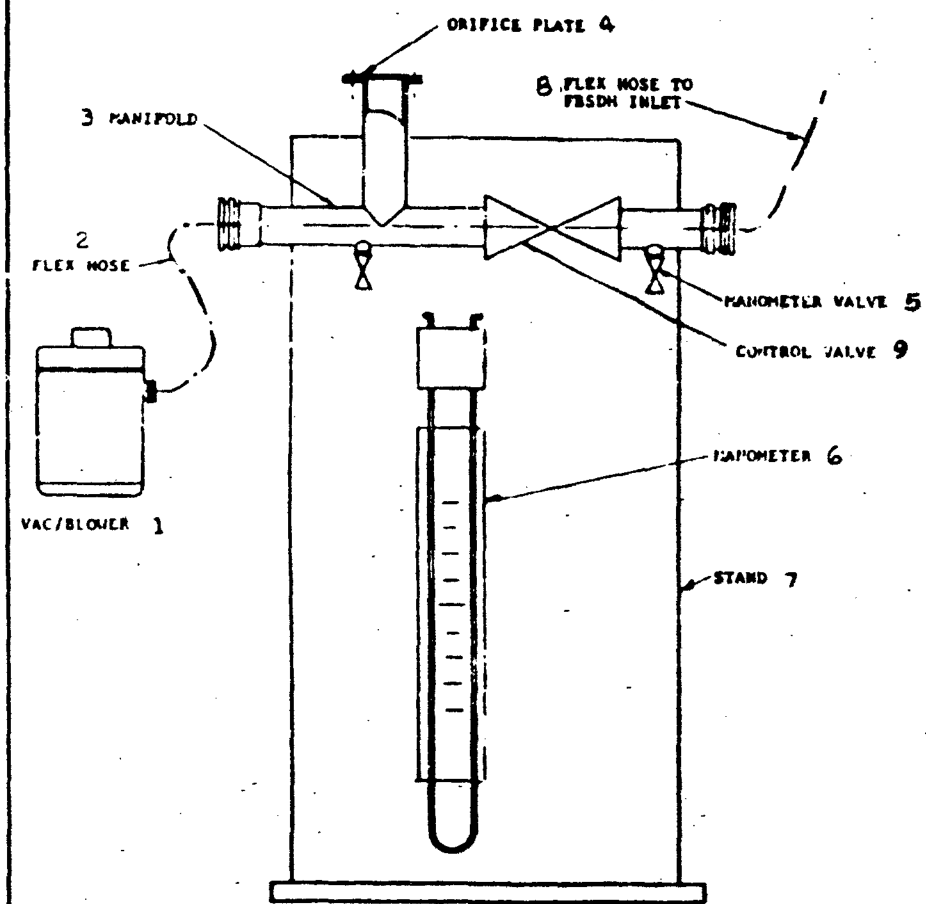


Figure 5.
Back View of FBSDH system with Cartridges in the Draw-Down Configuration.



FBSDH
FLOW SCHEMATIC

Figure 6



LIST OF MATERIAL

NO REQD	ITEM NO	DESCRIPTION
1	1	VAC/BLOWER, SIM OR EQUAL TO DAYTON 3271C (W W GRAINGER) WET OR DRY VAC. 10 GAL, 1.7 HP, 9.5 A, 120 VAC, 85" STATIC PRES 96 CFM WITH 1½" HOSE.
1	2	FLEX HOSE FURNISHED WITH VAC/BLOWER
1	3	MANIFOLD, MAKE FROM 1" IPS THIN WALL COPPER OR ALUM TUBING
AS REQD	4	ORIFICE PLATES 0.05" THICK, STEEL OR AL
2	5	VALVES FOR ¼" O D TUBE
1	6	MANOMETER, SIM OR EQUAL TO DWYER U TUBE, SERIES 1223D, 8" WATER RANGE (4-0-4), RED GAGE OIL TYPE WITH OVER PRESS TRAP
1	7	STAND, MAKE TO SUIT
1	8	1½" I D THIN WALL FLEX HOSE, LENGTH TO SUIT
1	9	1" I P S LOW PRESSURE GLOBE VALVE

FIGURE 7
TEST EQUIPMENT

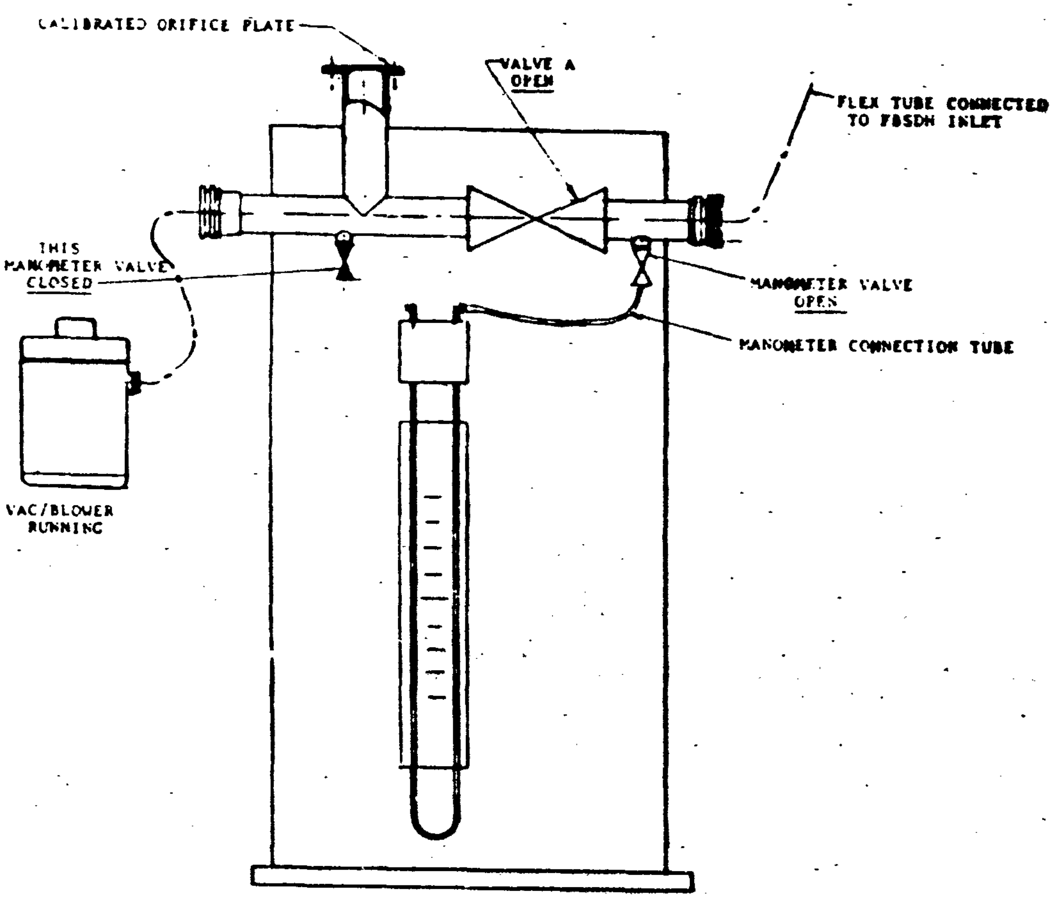


FIGURE 8
PRESSURE AND VACUUM TEST

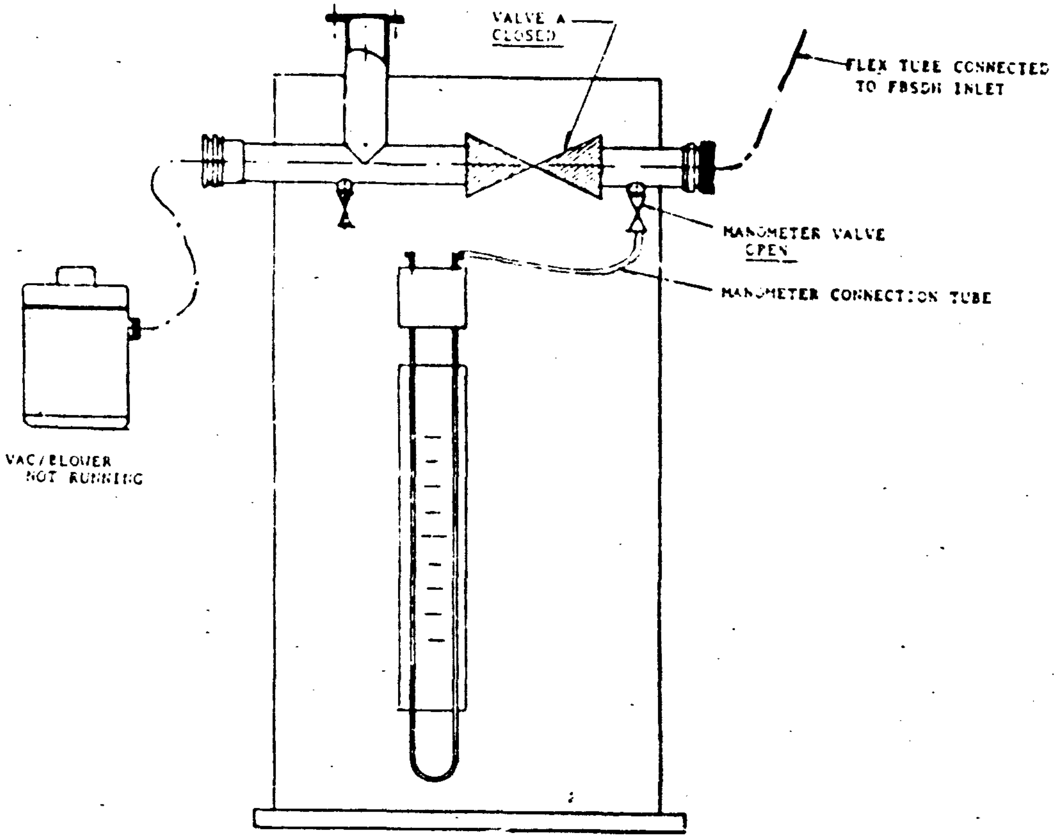


FIGURE 9

PRESSURE AND VACUUM DECAY TEST

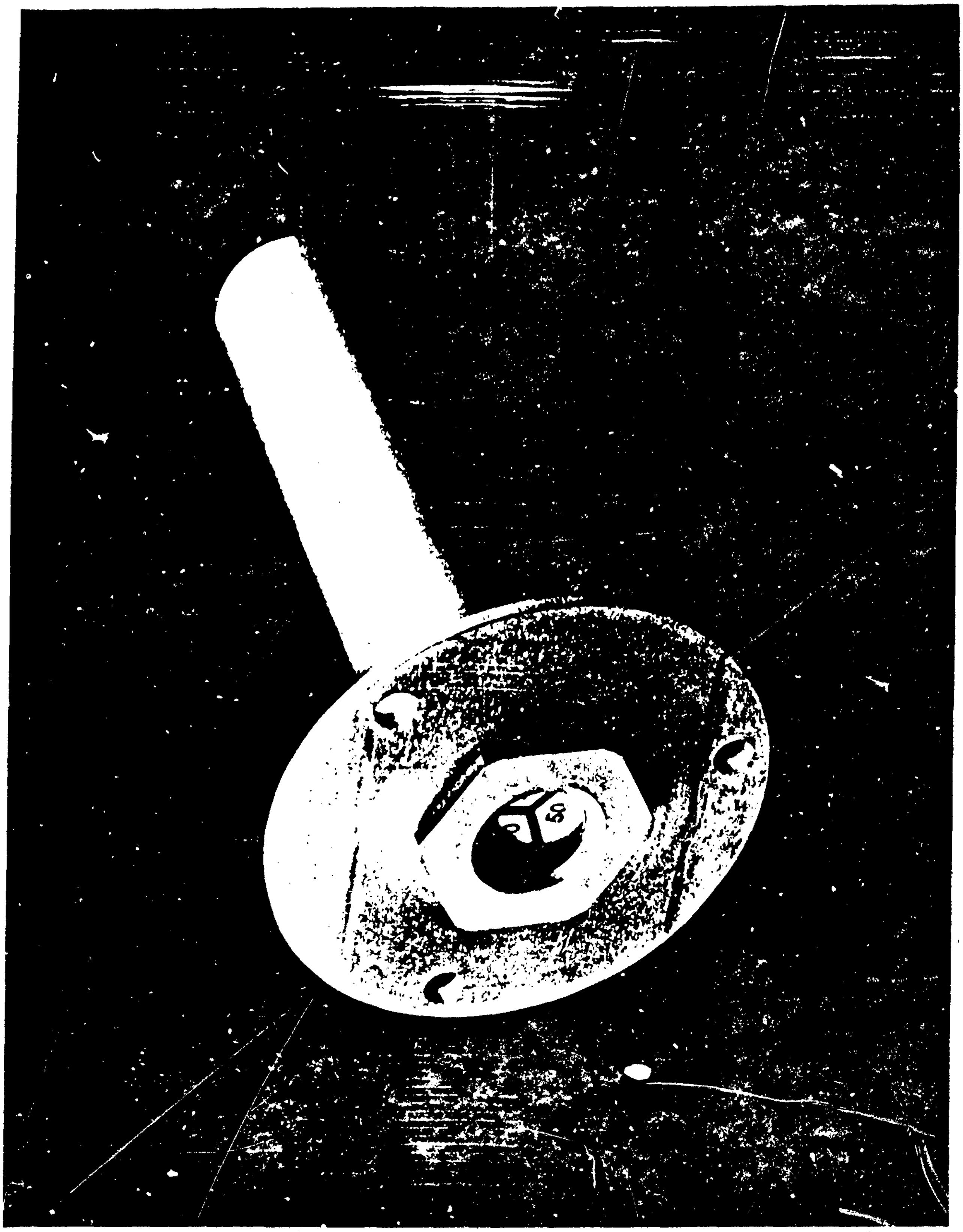
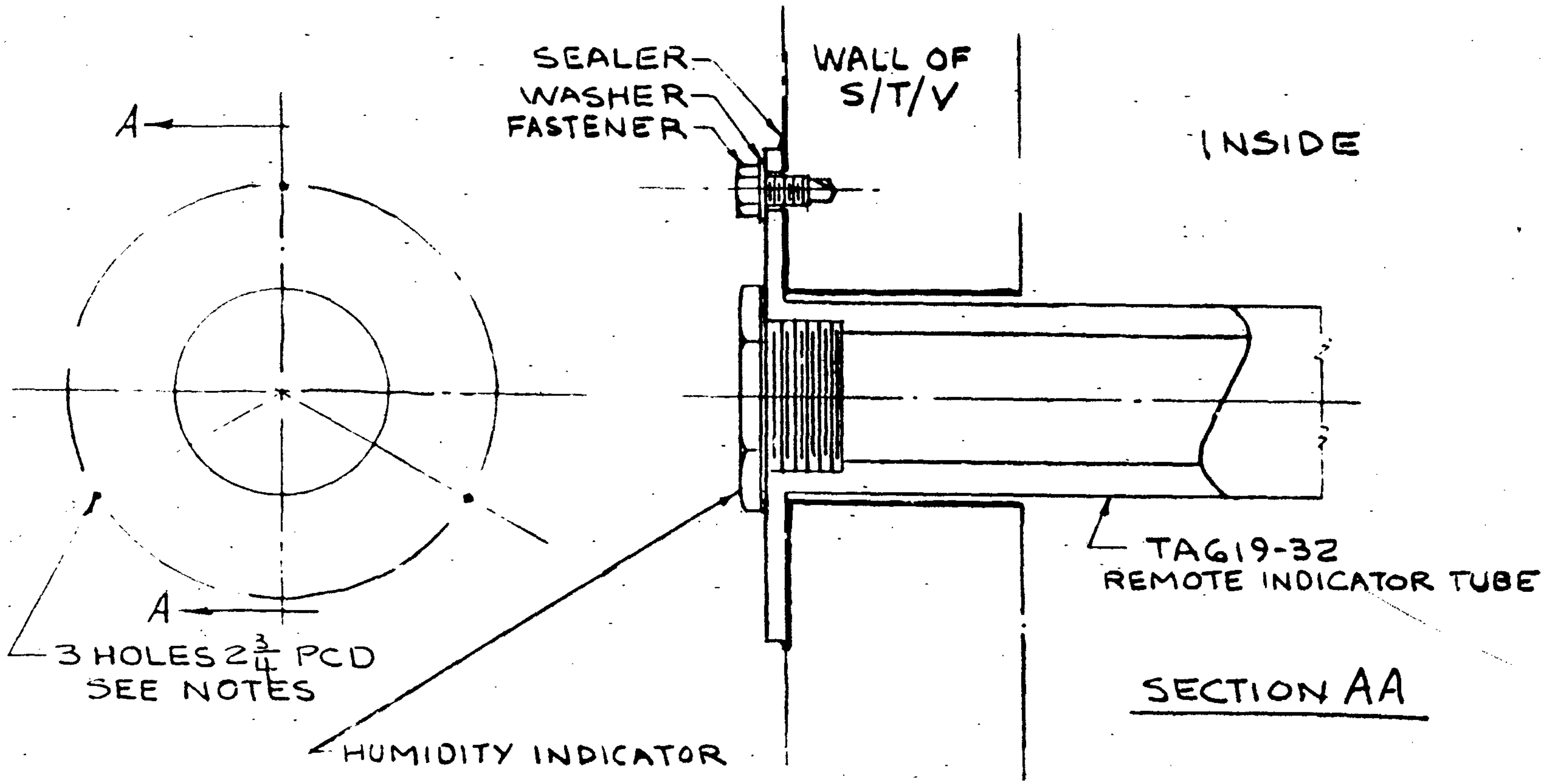


Figure 10.
Humidity Indicator



NOTES

1. INDICATOR TUBE FLANGE MAY BE USED AS TEMPLATE FOR HOLES.
2. STAR "DRILL&TAP" SCREWS, SHEETMETAL SCREWS OR RIVETS MAY BE USED. MOUNTING FLANGE HOLES ARE 1/4" DIA TO PROVIDE LIBERAL CLEARANCE FOR #10 SCREWS. HARDWARE IS NOT FURNISHED BY AGM.

TEMPLATE FOR INSTALLATION OF REMOTE

HUMIDITY INDICATOR TUBE

FULL SIZE

Figure 11

Figure 12.
Field Layout at SM-ALC/DST, McClellan AFB CA

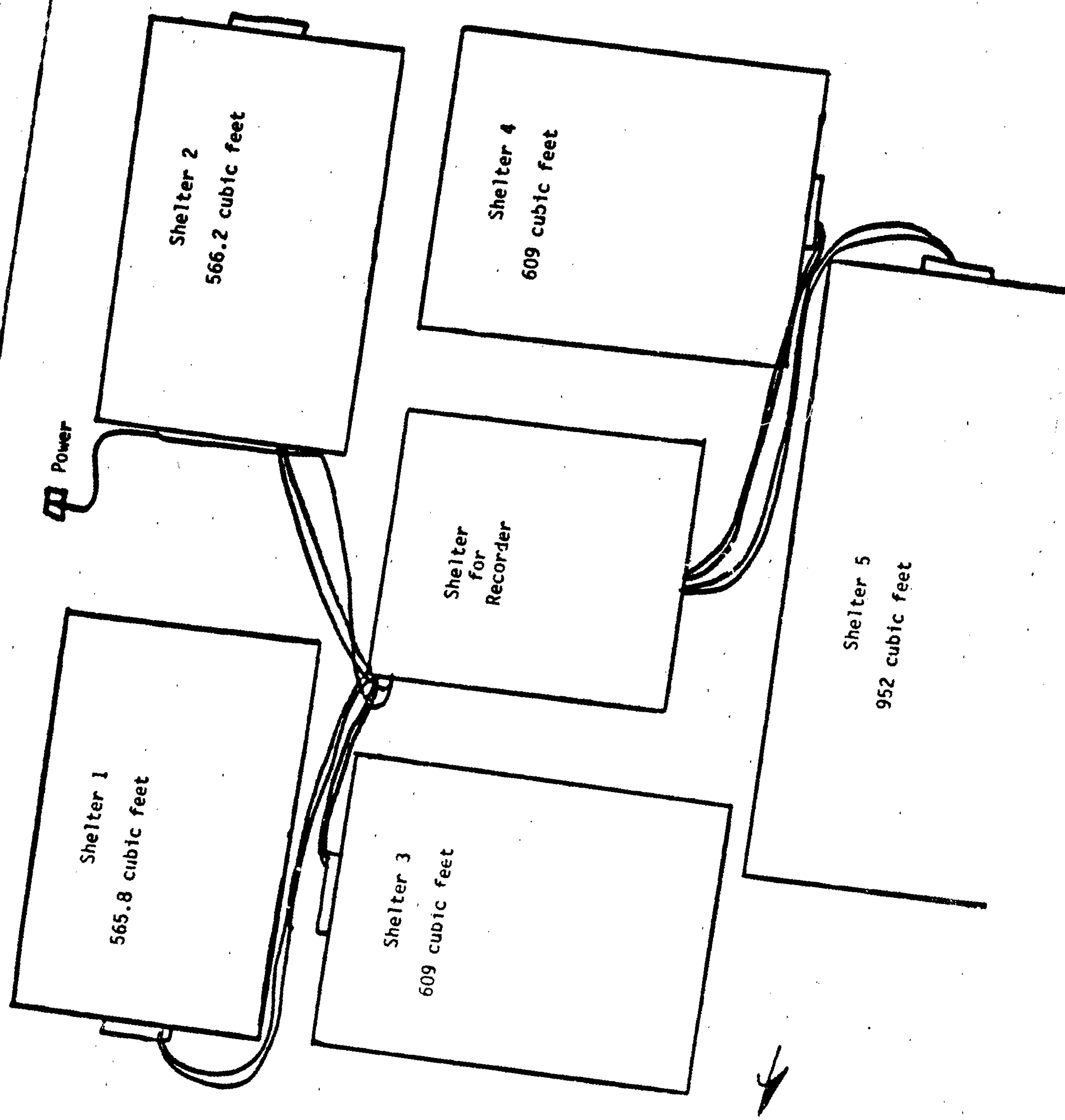
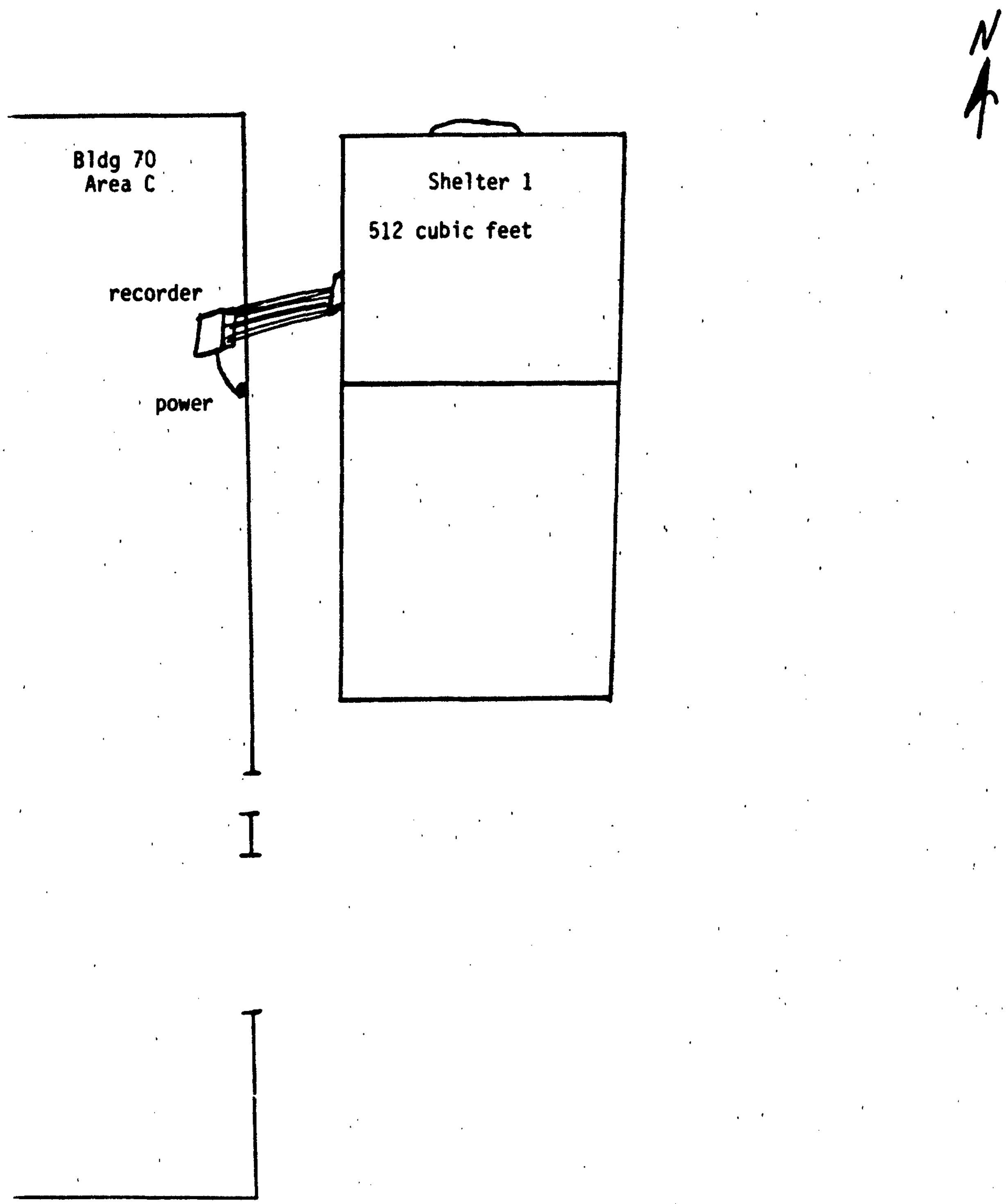
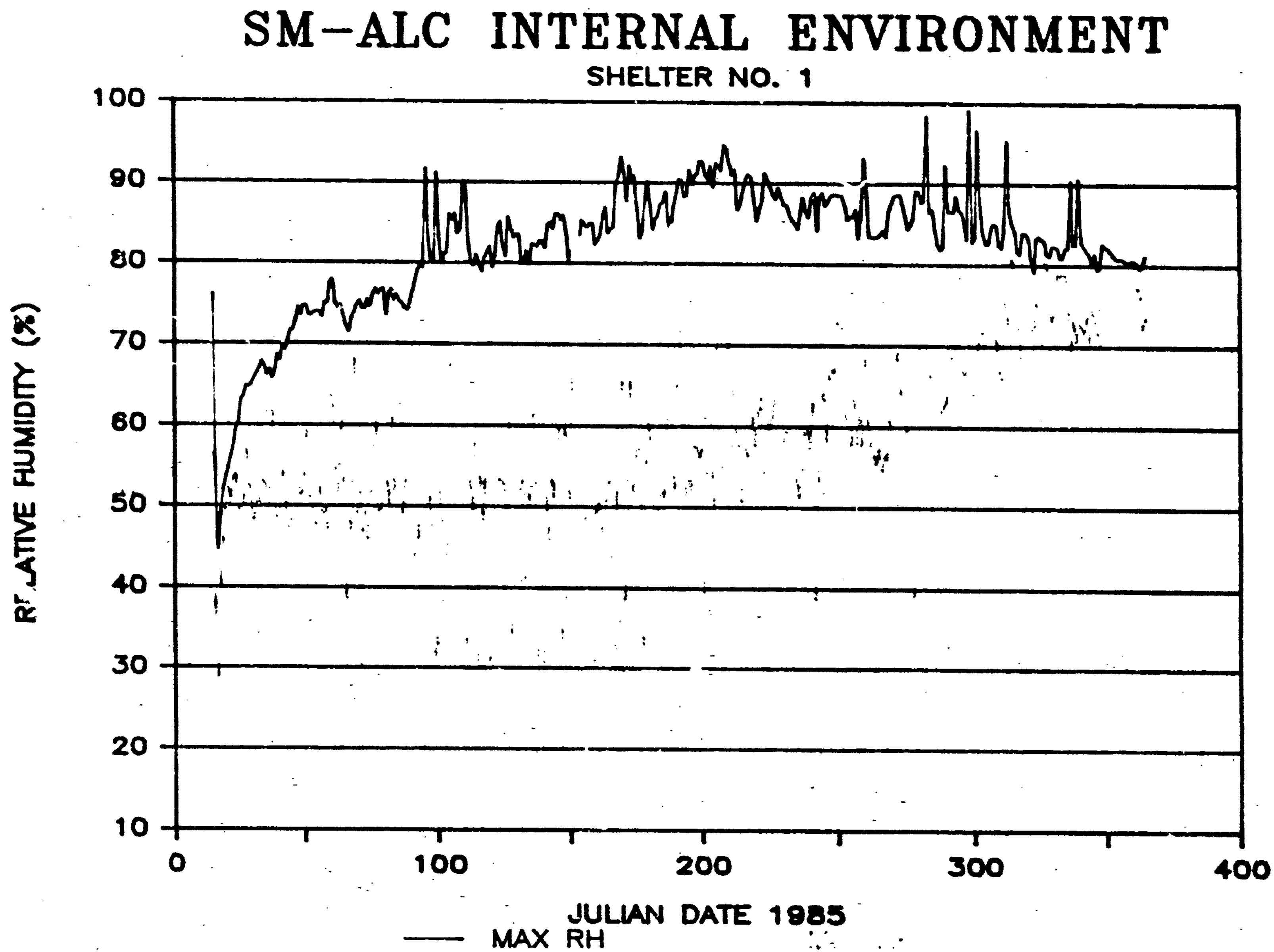


Figure 13.
Field Layout at HQ AFLC/DSTZD, Wright-Patt AFB OH





SM-ALC INTERNAL ENVIRONMENT
SHELTER NO. 1
RELATIVE HUMIDITY (%)
100
90
80
70
60
50
40
30
20
10
0
100
200
300
400
JULIAN DATE 1985
MAX RH

Figure 14

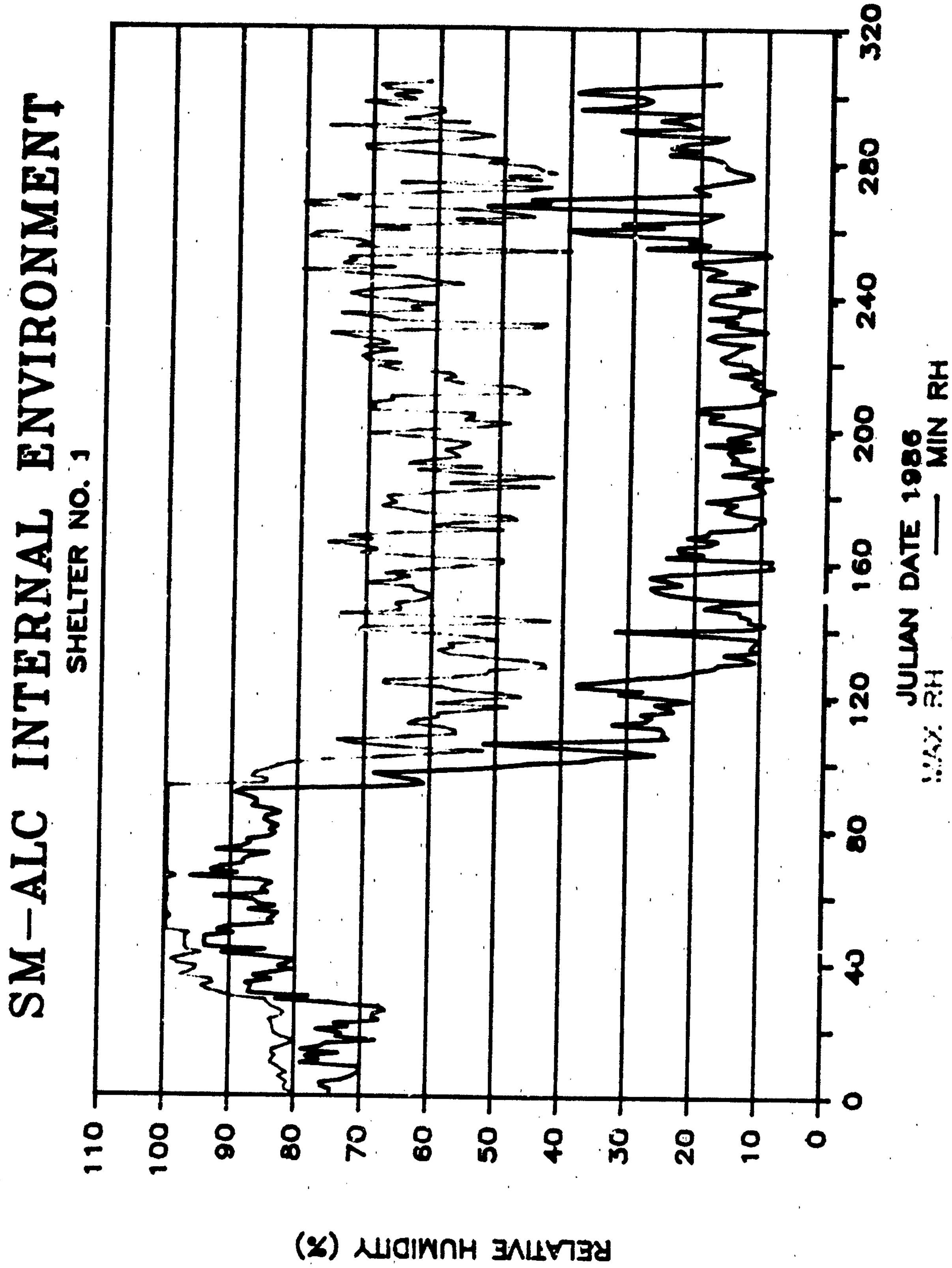

SM-ALC INTERNAL ENVIRONMENT
SHELTER NO. 1
RELATIVE HUMIDITY (%)
110
100
90
80
70
60
50
40
30
20
10
0
0
40
80
120
160
200
240
280
320
JULIAN DATE 1986
MAX RH
MIN RH

Figure 15

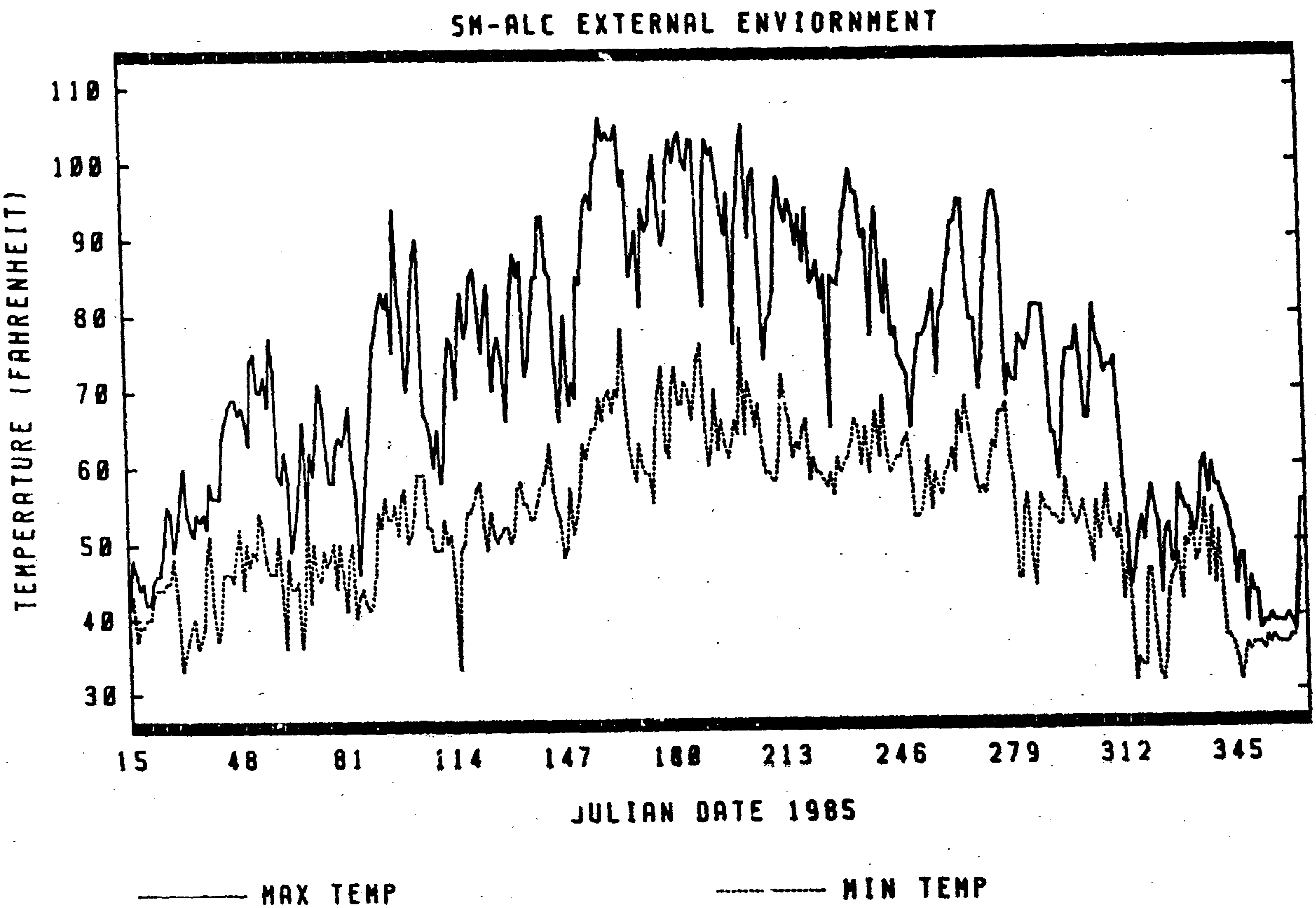

SM-ALC EXTERNAL ENVIORNMENT
TEMPERATURE (FAHRENHEIT)
110
100
90
80
70
60
50
40
30
15
48
81
114
147
180
213
246
279
312
345
JULIAN DATE 1985
MAX TEMP
MIN TEMP

Figure 16

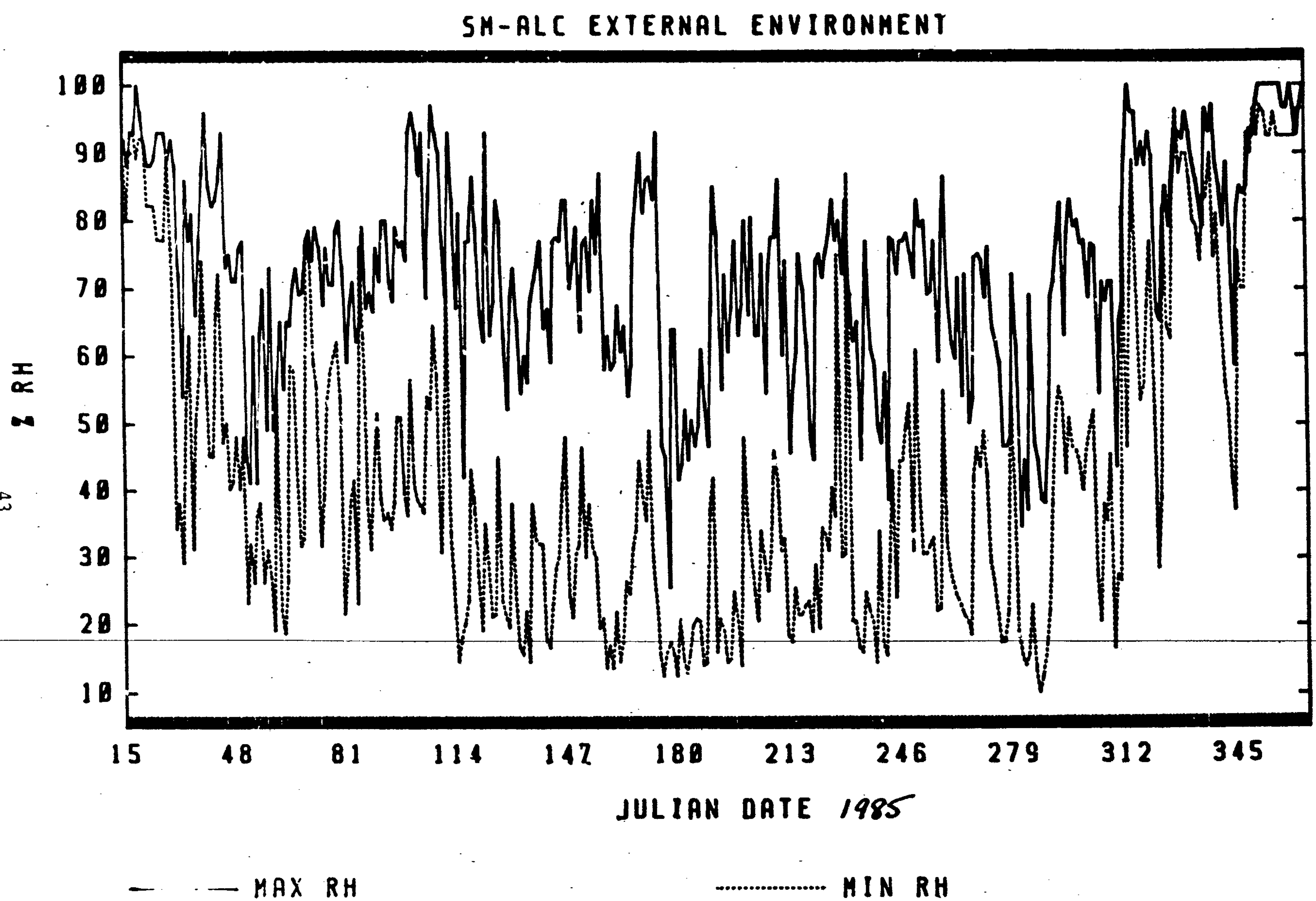

SM-ALC EXTERNAL ENVIRONMENT
% RH
100
90
80
70
60
50
40
30
20
10
15
48
81
114
147
180
213
246
279
312
345
JULIAN DATE 1985
MAX RH
MIN RH

Figure 17

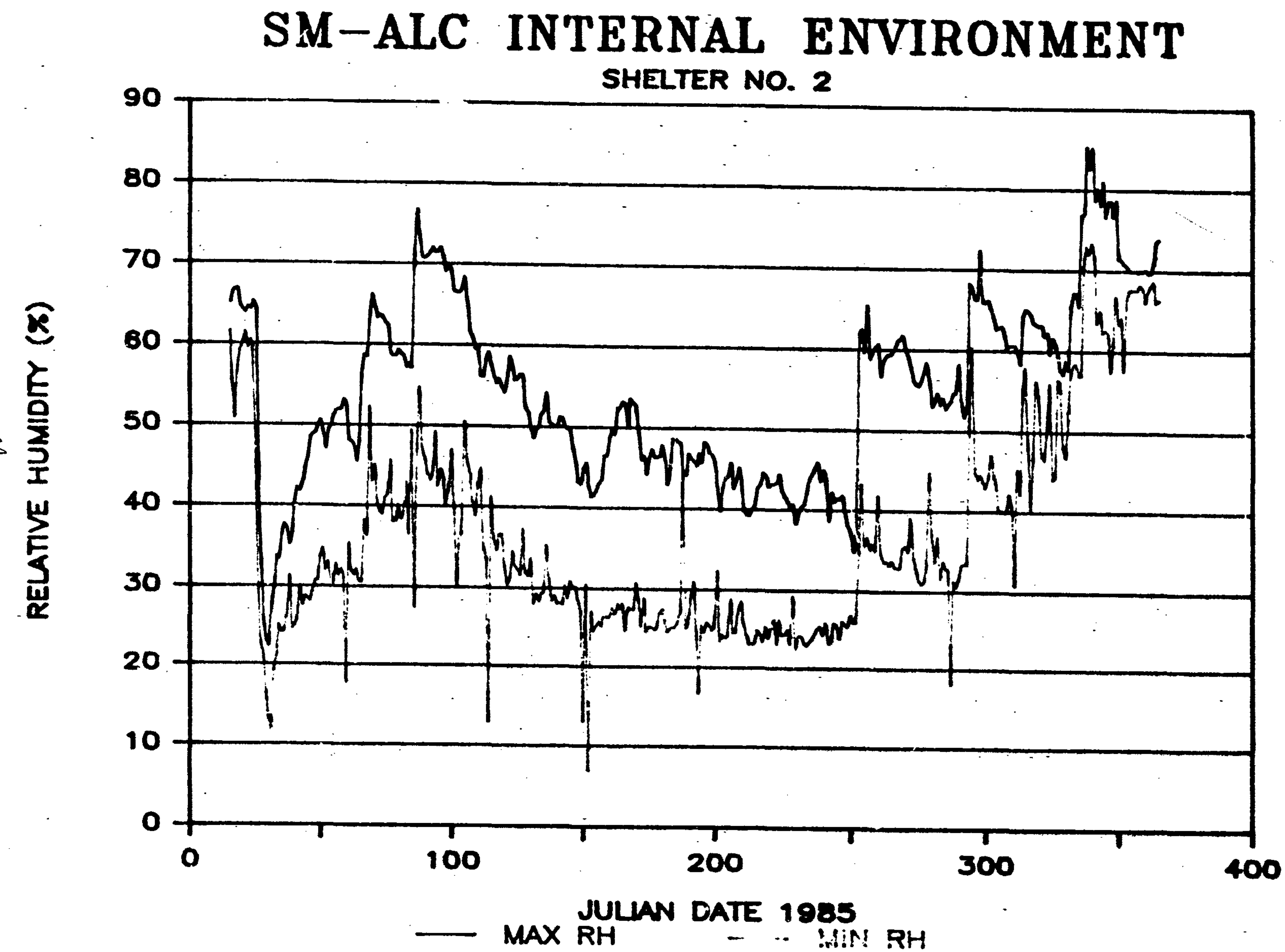

SM–ALC INTERNAL ENVIRONMENT
SHELTER NO. 2
RELATIVE HUMIDITY (%)
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
JULIAN DATE 1985
MAX RH
MIN RH

Figure 18

SM-ALC EXTERNAL ENVIRONMENT

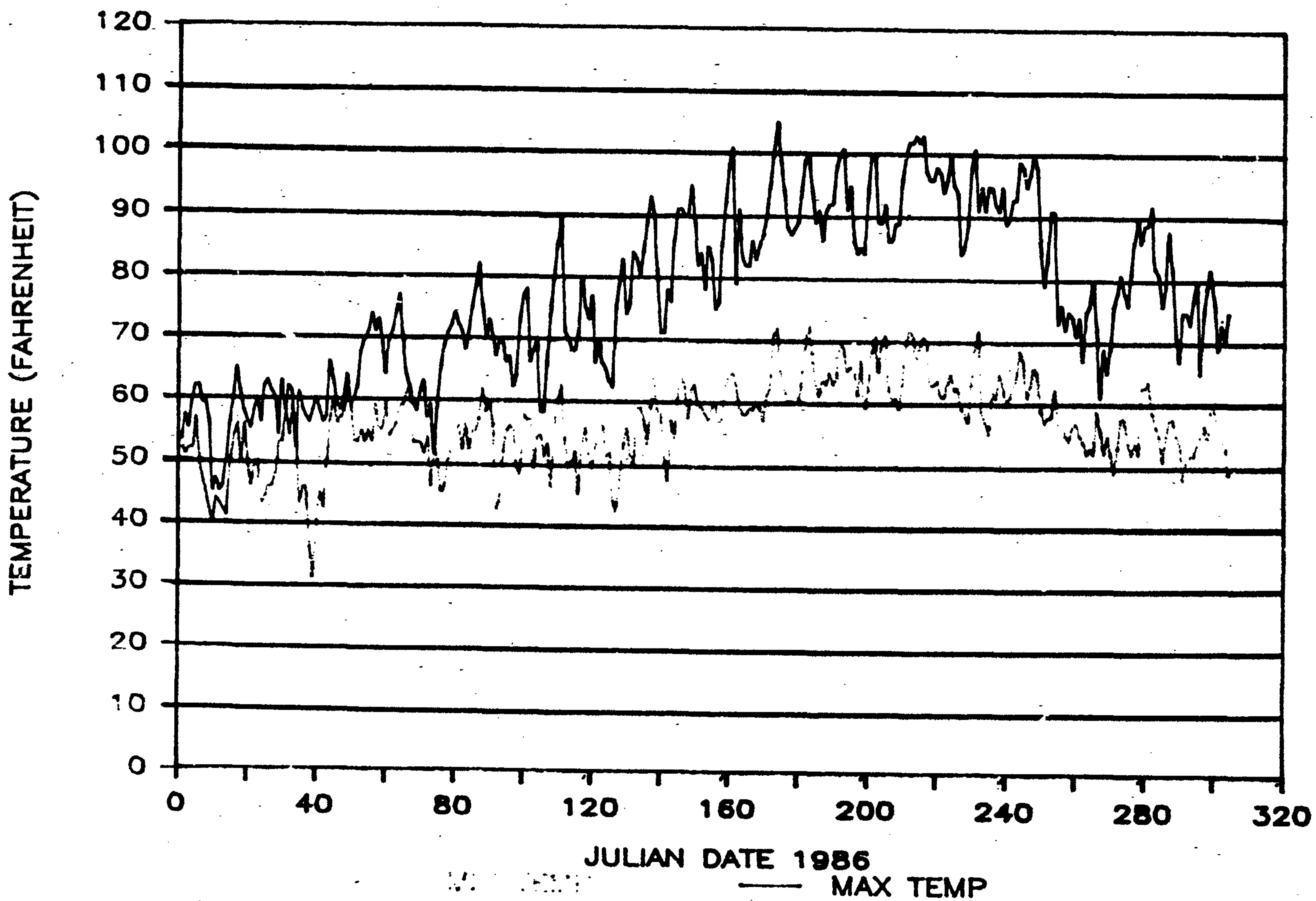


Figure 19

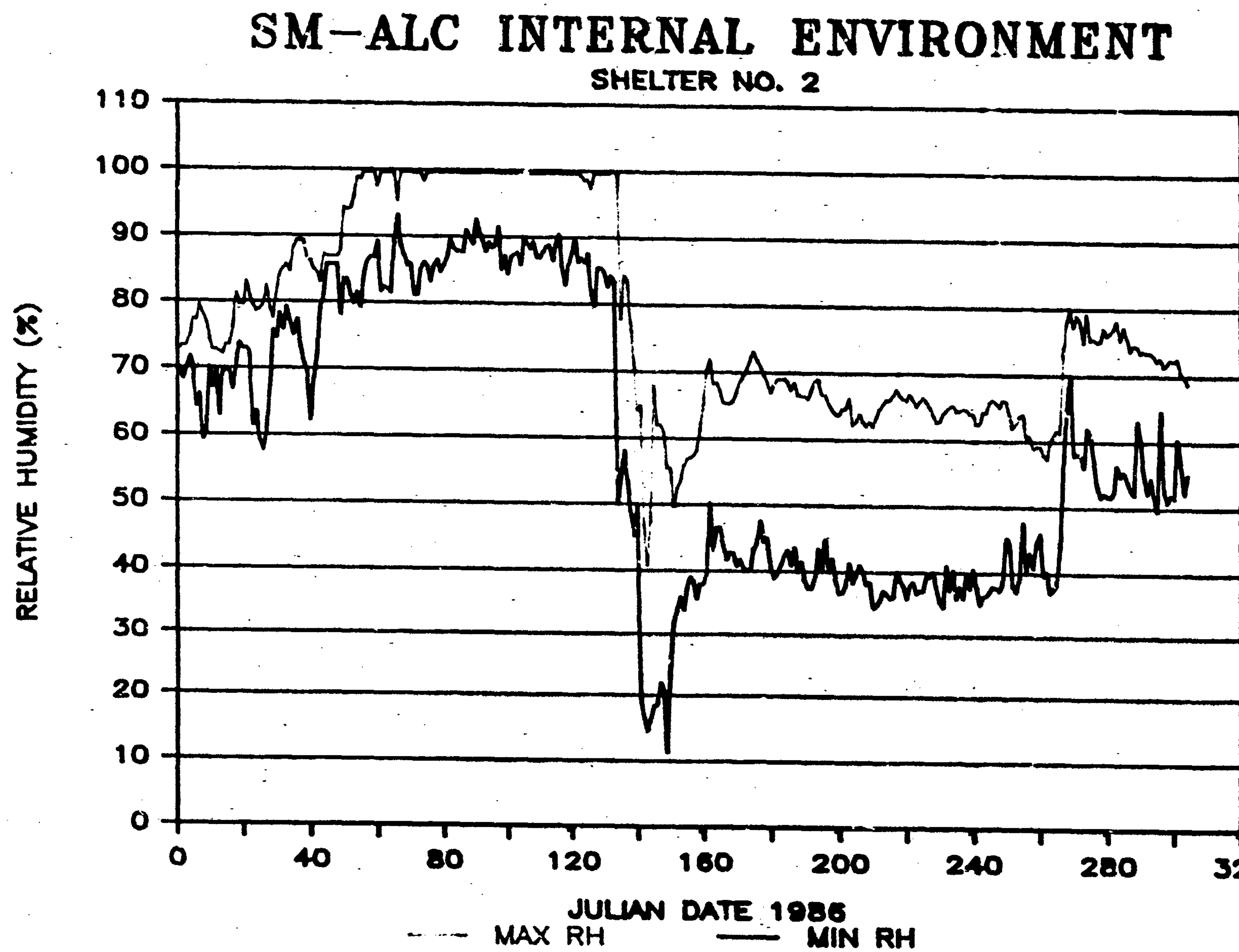
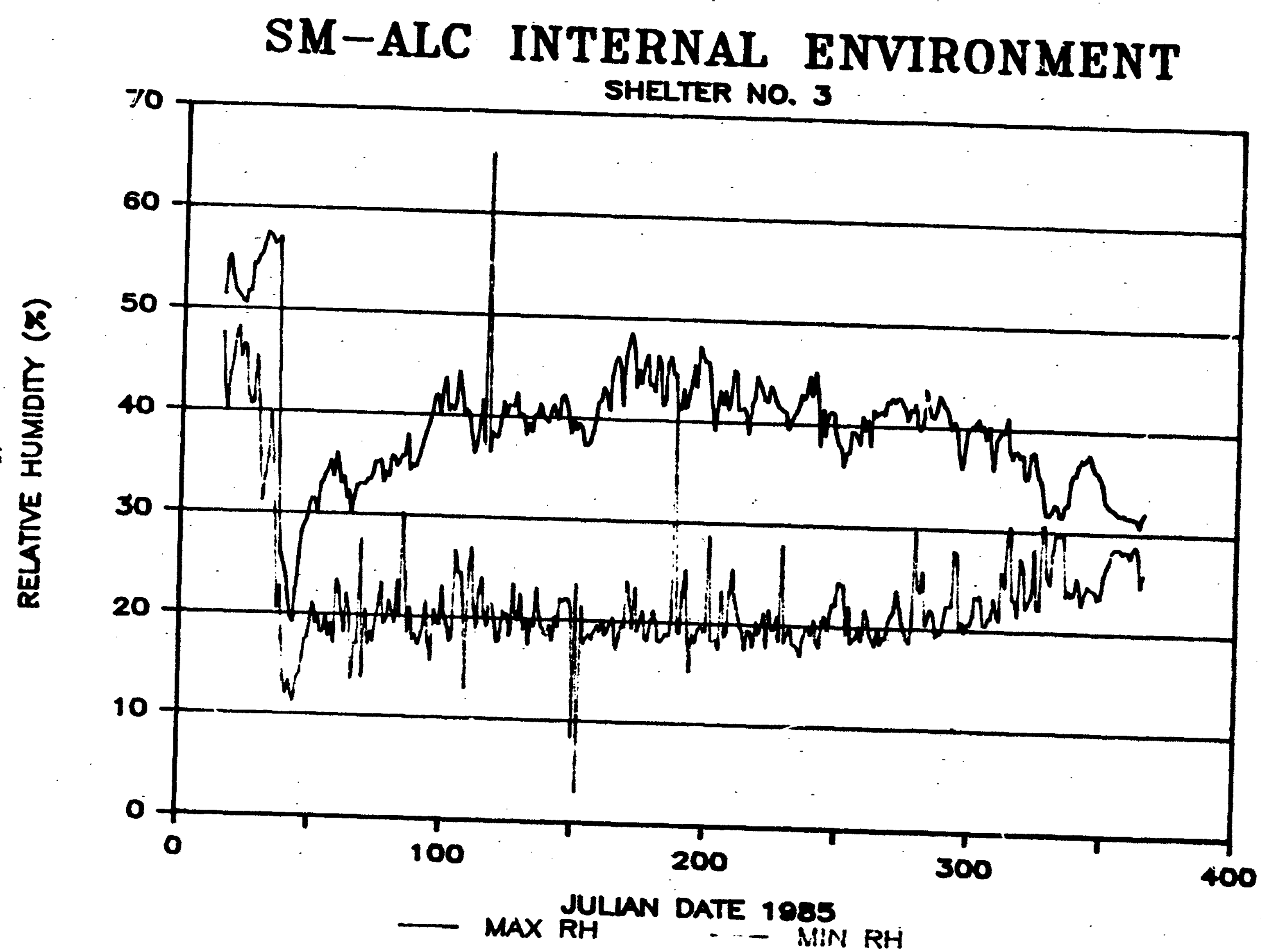

SM-ALC INTERNAL ENVIRONMENT
SHELTER NO. 2
RELATIVE HUMIDITY (%)
110
100
90
80
70
60
50
40
30
20
10
0
40
80
120
160
200
240
280
320
JULIAN DATE 1986
MAX RH
MIN RH

Figure 20



SM-ALC INTERNAL ENVIRONMENT
SHELTER NO. 3
RELATIVE HUMIDITY (%)
70
60
50
40
30
20
10
0
100
200
300
400
JULIAN DATE 1985
MAX RH
MIN RH

Figure 21

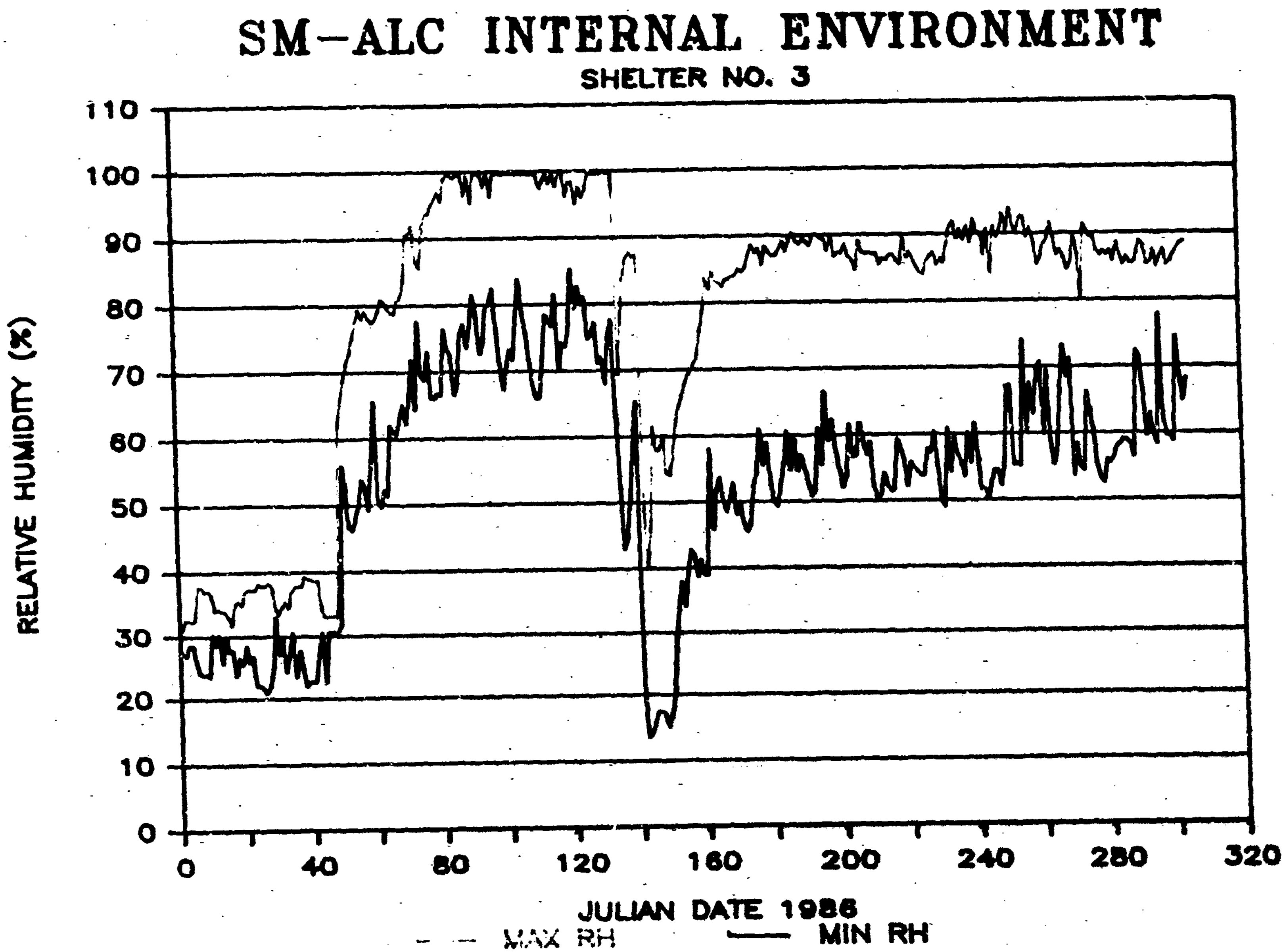

SM-ALC INTERNAL ENVIRONMENT
SHELTER NO. 3
RELATIVE HUMIDITY (%)
110
100
90
80
70
60
50
40
30
20
10
0
0
40
80
120
160
200
240
280
320
JULIAN DATE 1986
MAX RH
MIN RH

Figure 22

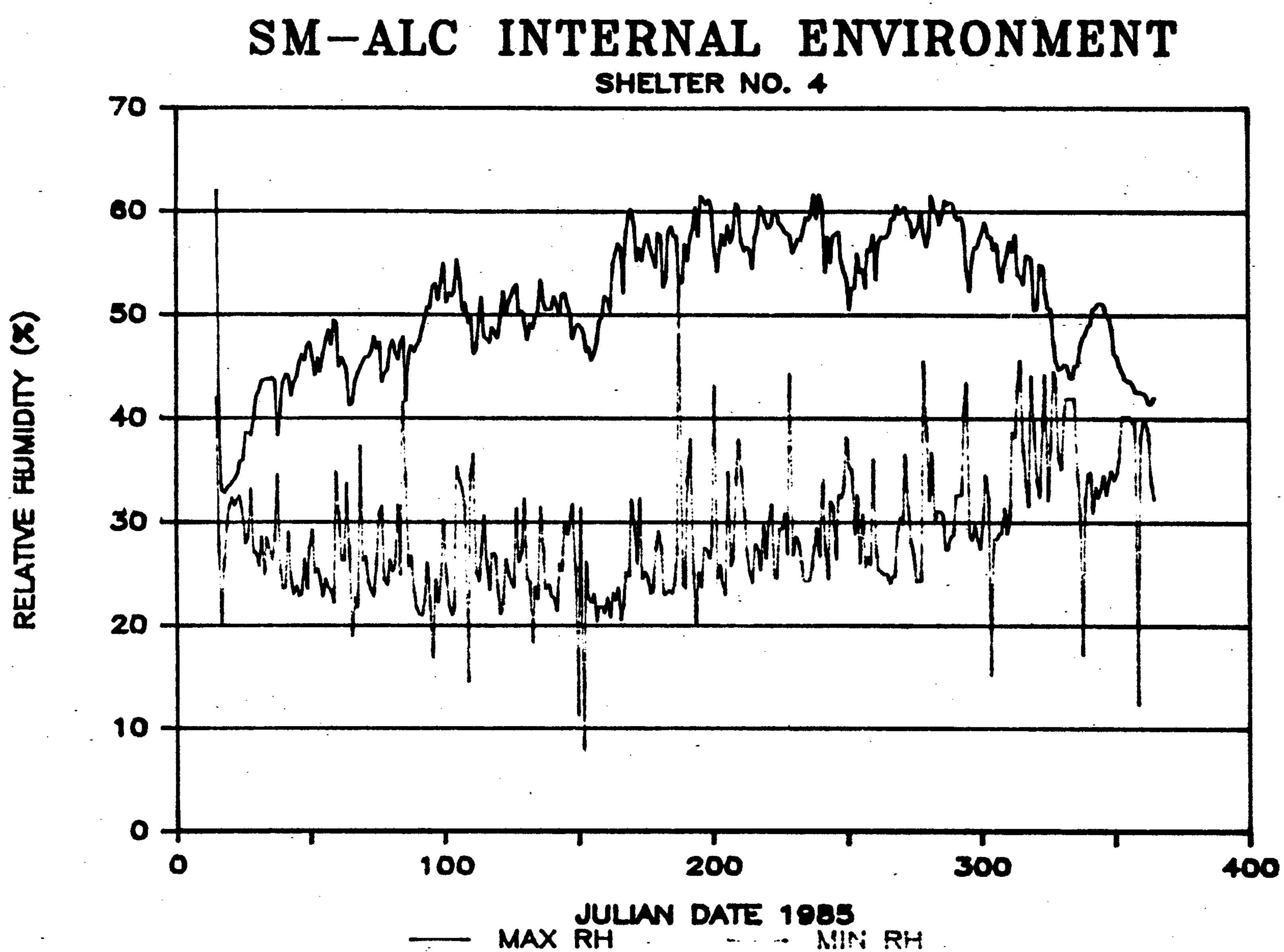

SM-ALC INTERNAL ENVIRONMENT
SHELTER NO. 4
RELATIVE HUMIDITY (%)
70
60
50
40
30
20
10
0
100
200
300
400
JULIAN DATE 1985
MAX RH
MIN RH

Figure 23

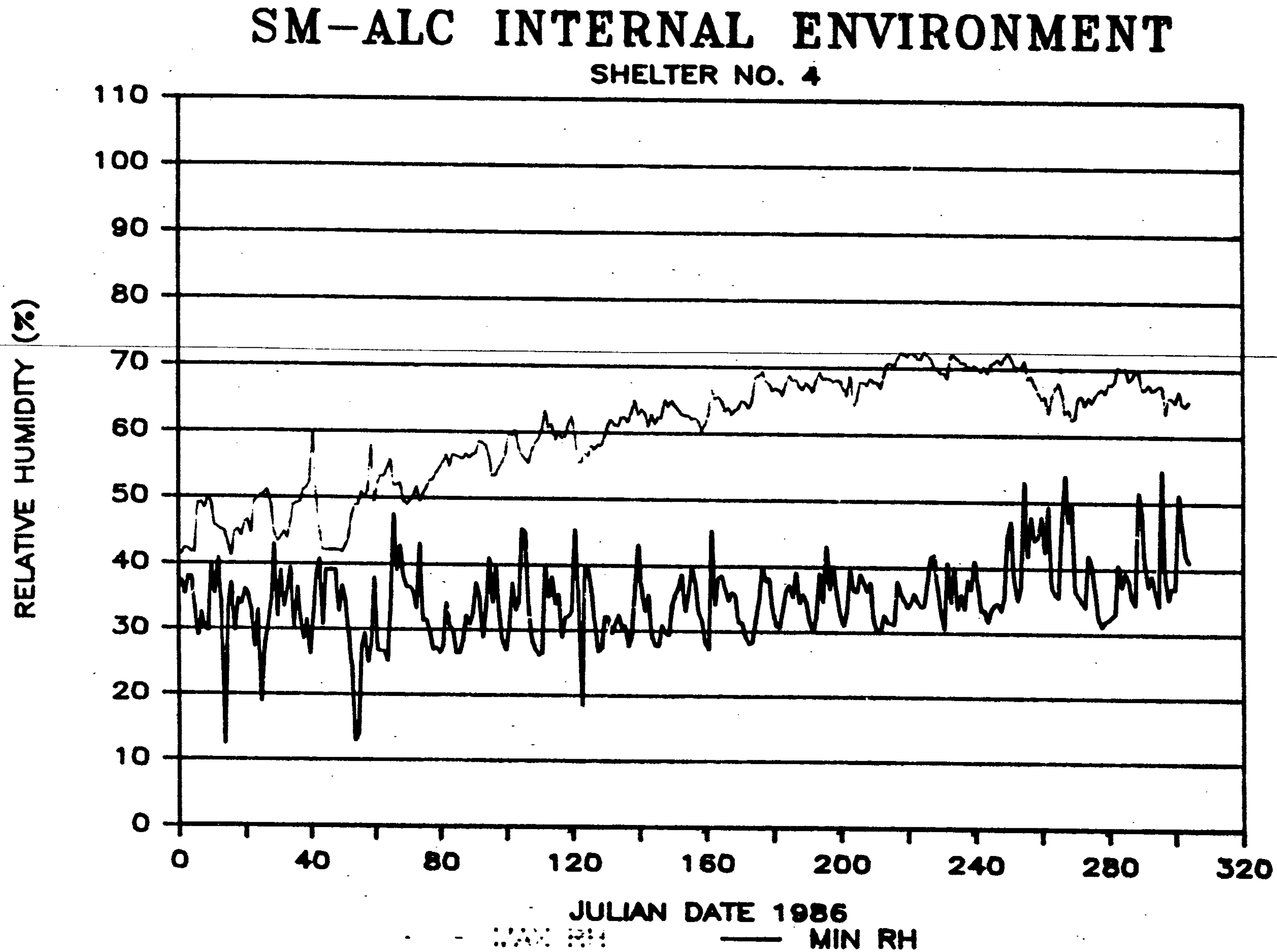

SM–ALC INTERNAL ENVIRONMENT
SHELTER NO. 4
RELATIVE HUMIDITY (%)
110
100
90
80
70
60
50
40
30
20
10
0
0
40
80
120
160
200
240
280
320
JULIAN DATE 1986
MIN RH

Figure 24

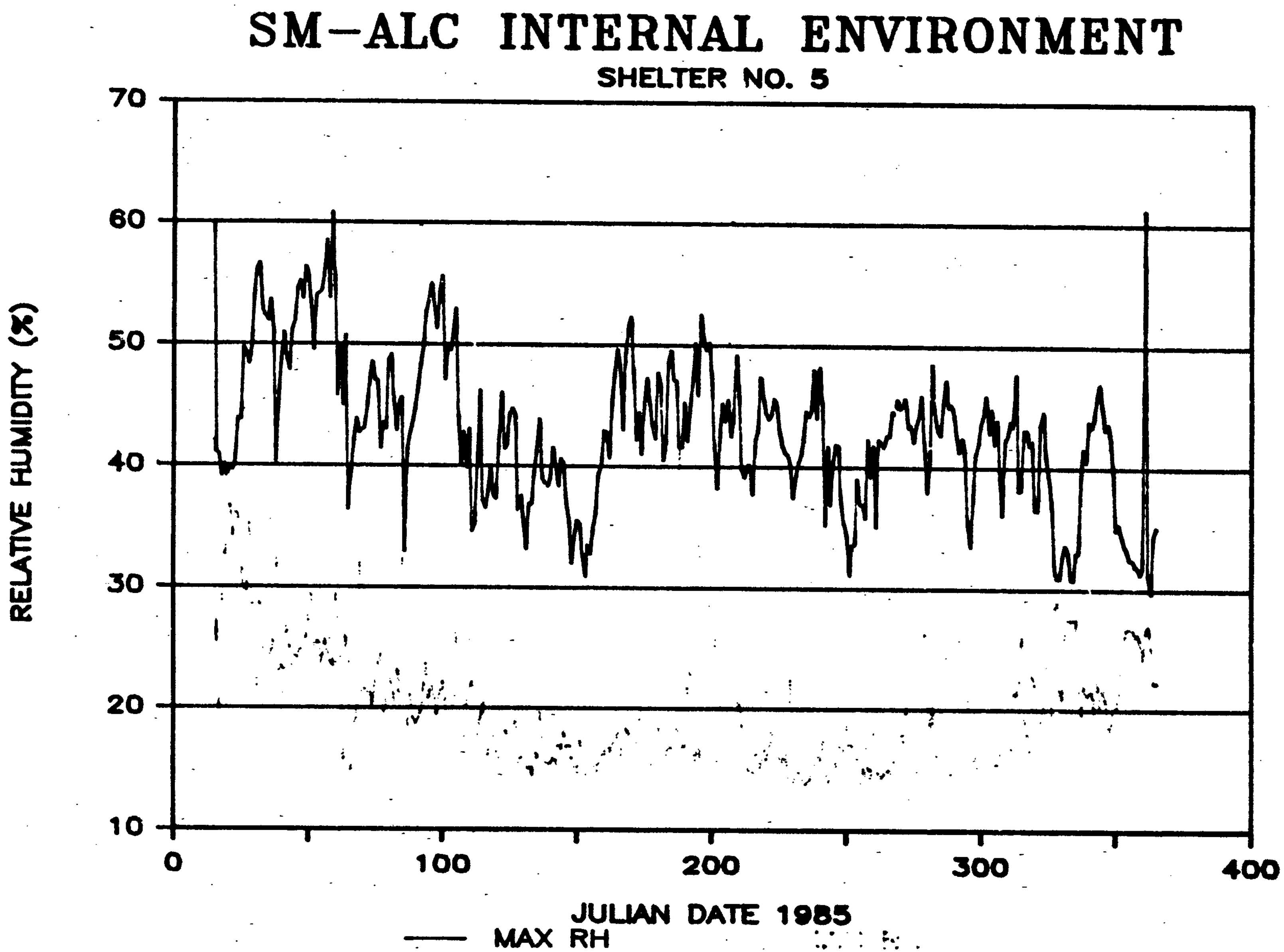

SM-ALC INTERNAL ENVIRONMENT
SHELTER NO. 5
RELATIVE HUMIDITY (%)
70
60
50
40
30
20
10
0
100
200
300
400
JULIAN DATE 1985
MAX RH

Figure 25

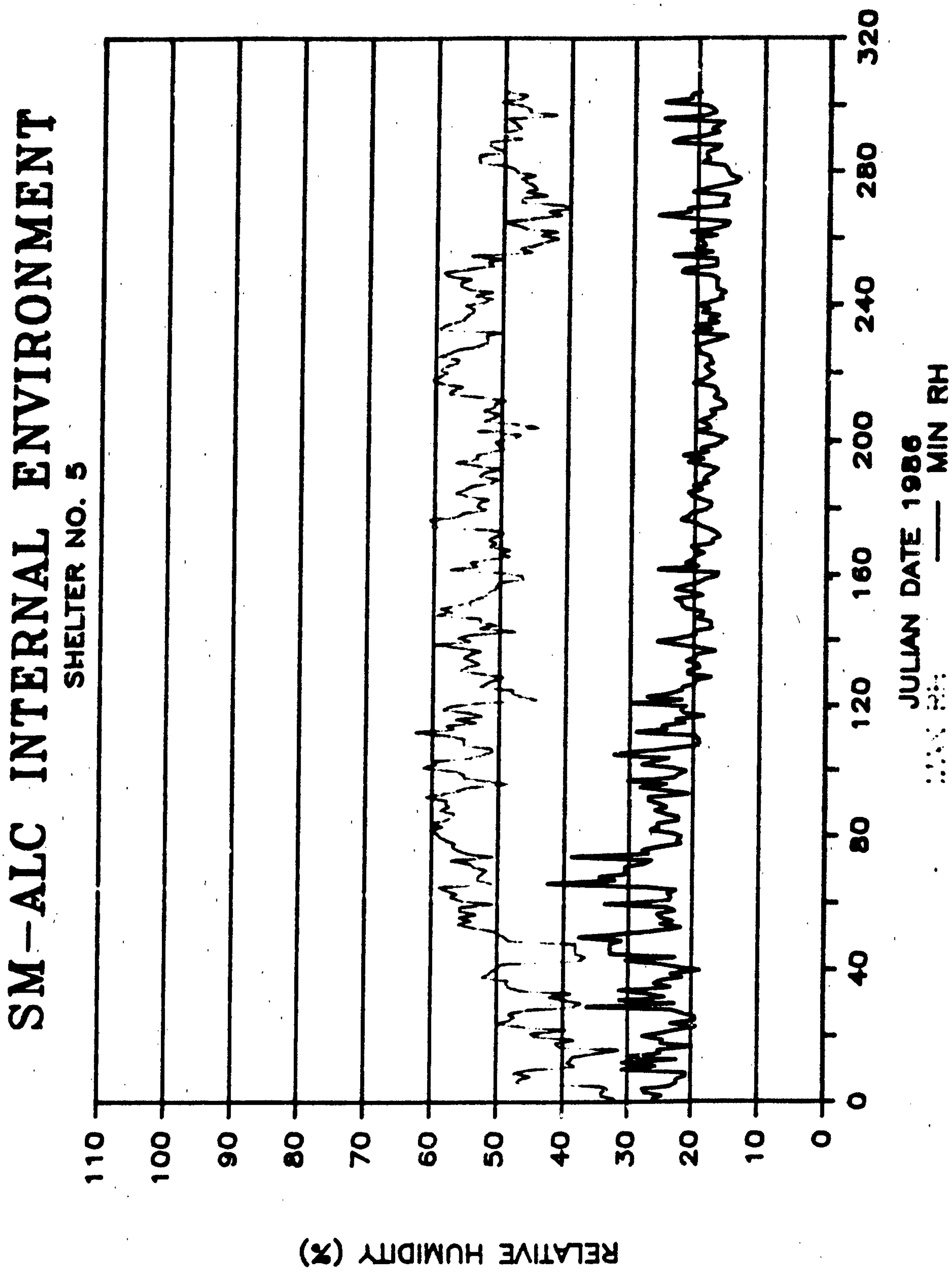

SM-ALC INTERNAL ENVIRONMENT
SHELTER NO. 5
RELATIVE HUMIDITY (%)
0
10
20
30
40
50
60
70
80
90
100
110
JULIAN DATE 1986
0
40
80
120
160
200
240
280
320
MIN RH

Figure 26

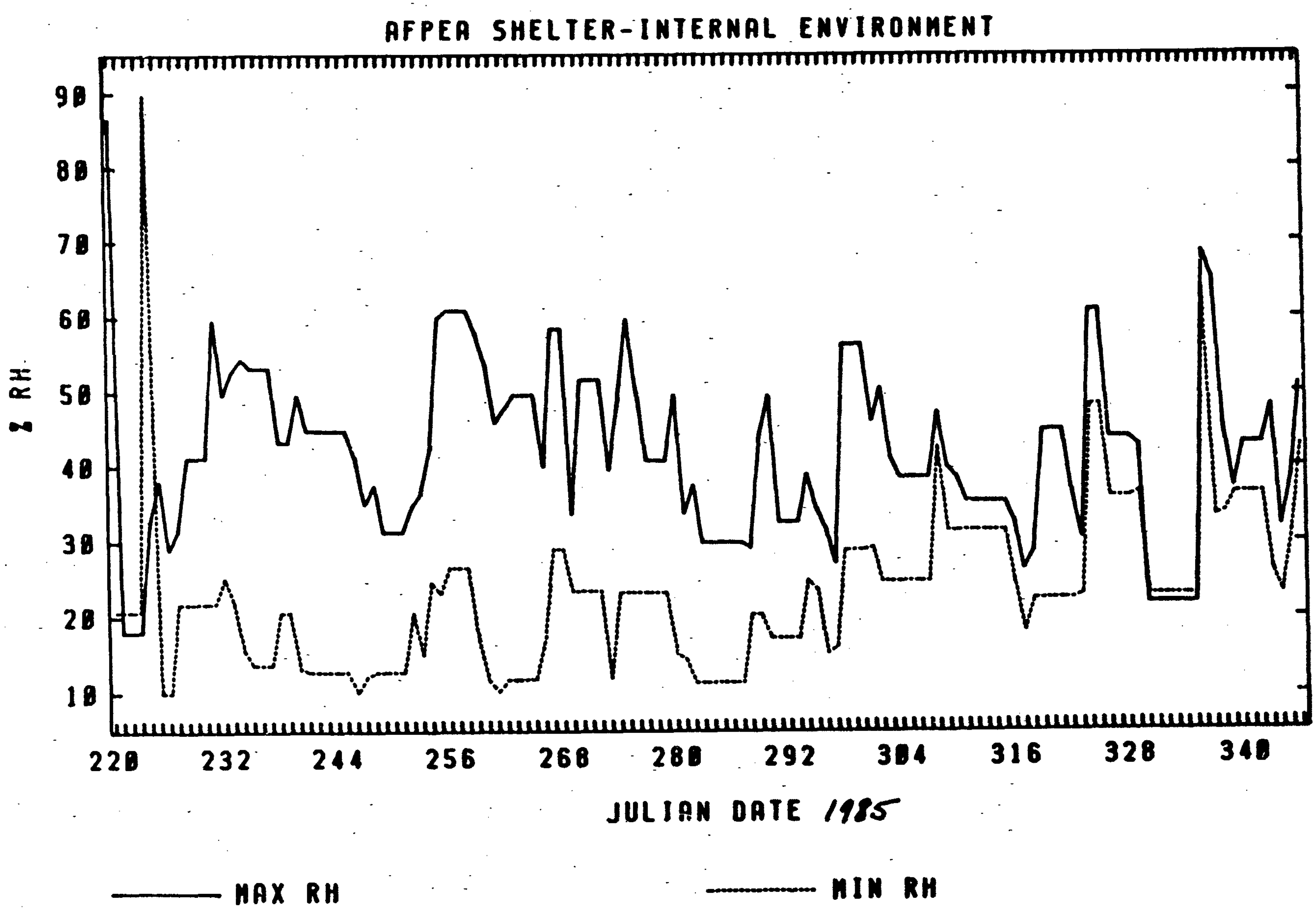
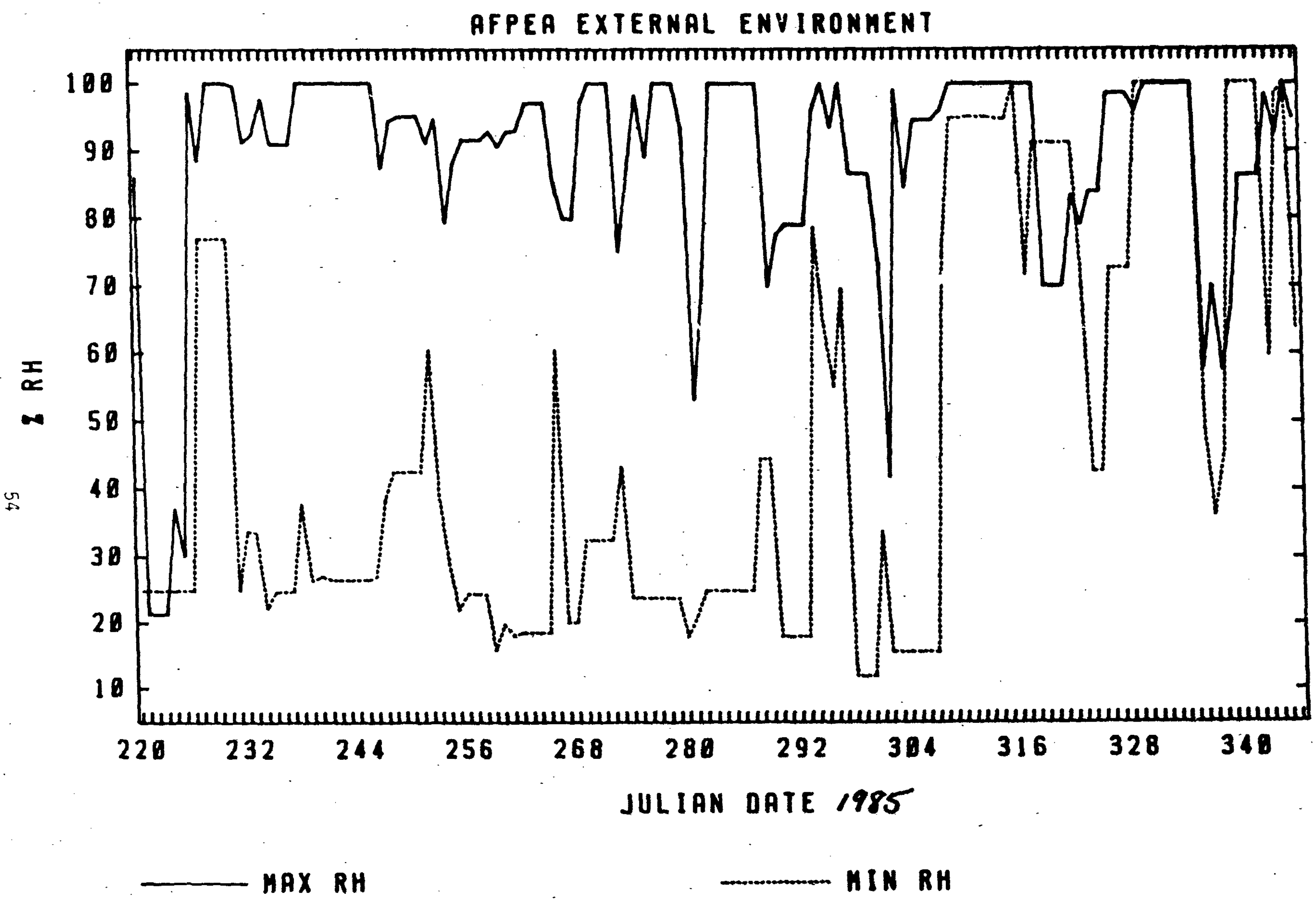

AFPEA SHELTER-INTERNAL ENVIRONMENT
% RH
90
80
70
60
50
40
30
20
10
220
232
244
256
268
280
292
304
316
328
340
JULIAN DATE 1985
MAX RH
MIN RH

Figure 27



AFPEA EXTERNAL ENVIRONMENT
% RH
100
90
80
70
60
50
40
30
20
10
220
232
244
256
268
280
292
304
316
328
340
JULIAN DATE 1985
MAX RH
MIN RH

Figure 28

AFPEA INTERNAL ENVIRONMENT

F.B.S.D.H. SYSTEM

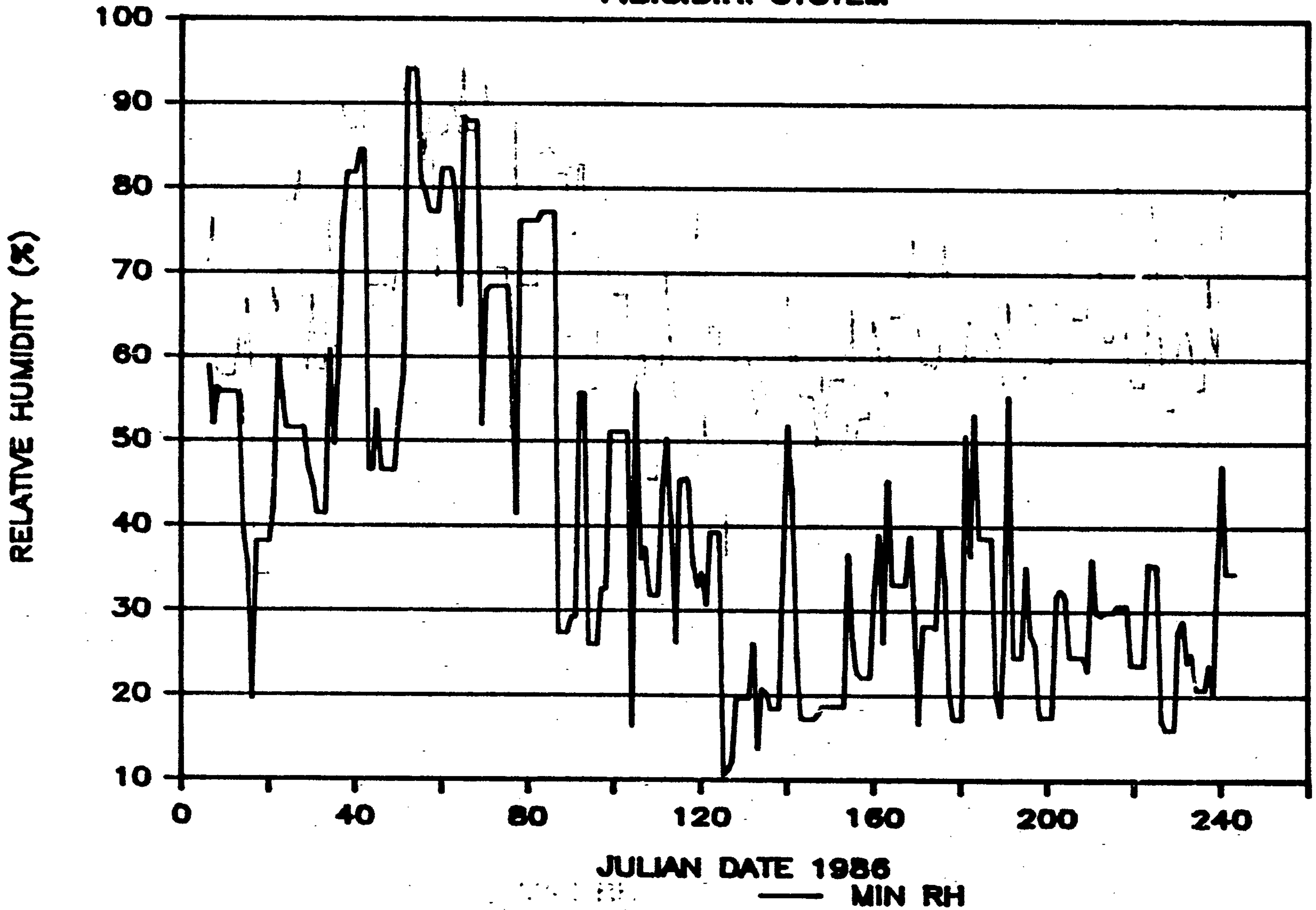


Figure 29

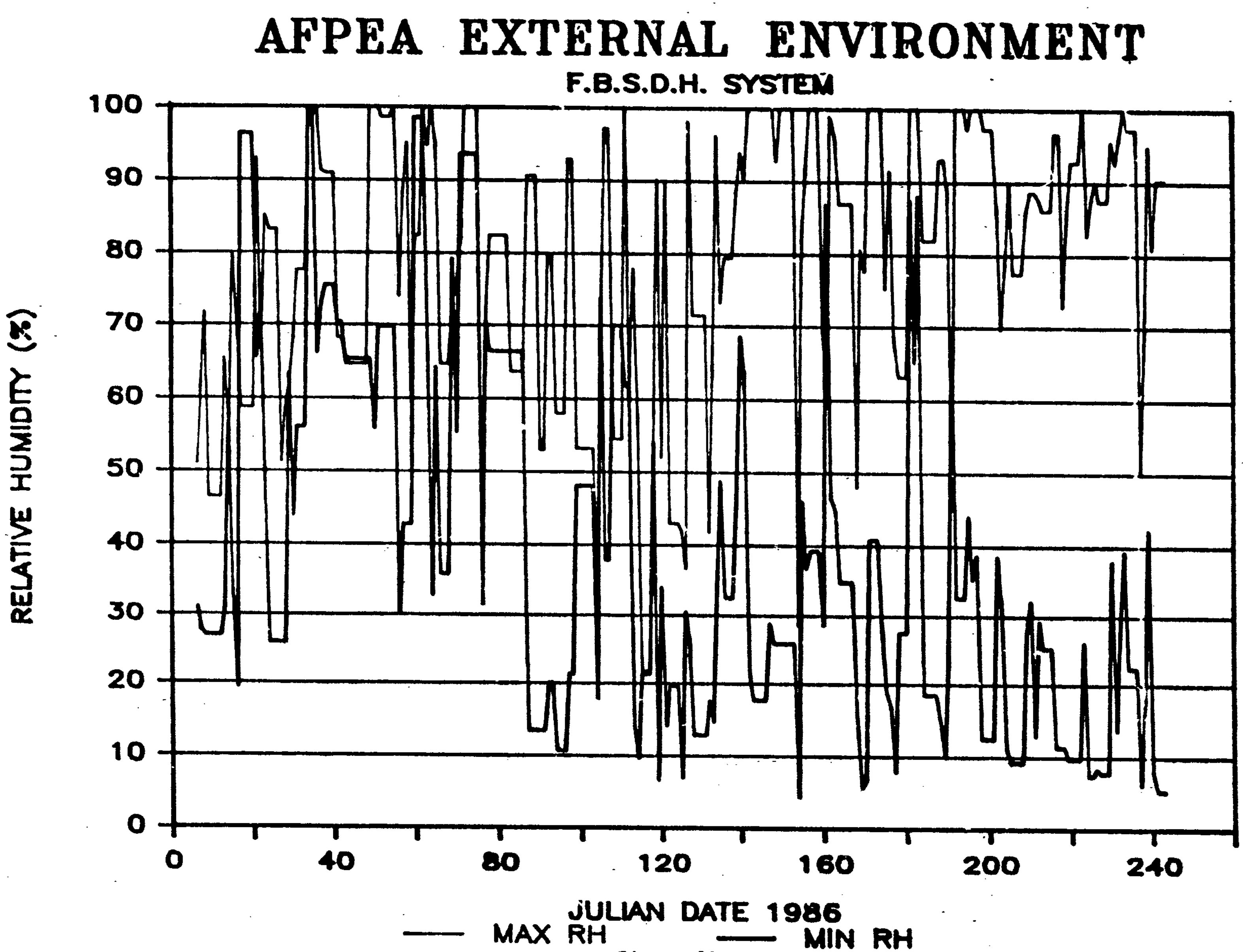

AFPEA EXTERNAL ENVIRONMENT
F.B.S.D.H. SYSTEM
RELATIVE HUMIDITY (%)
100
90
80
70
60
50
40
30
20
10
0
0
40
80
120
160
200
240
JULIAN DATE 1986
MAX RH
MIN RH

Figure 30

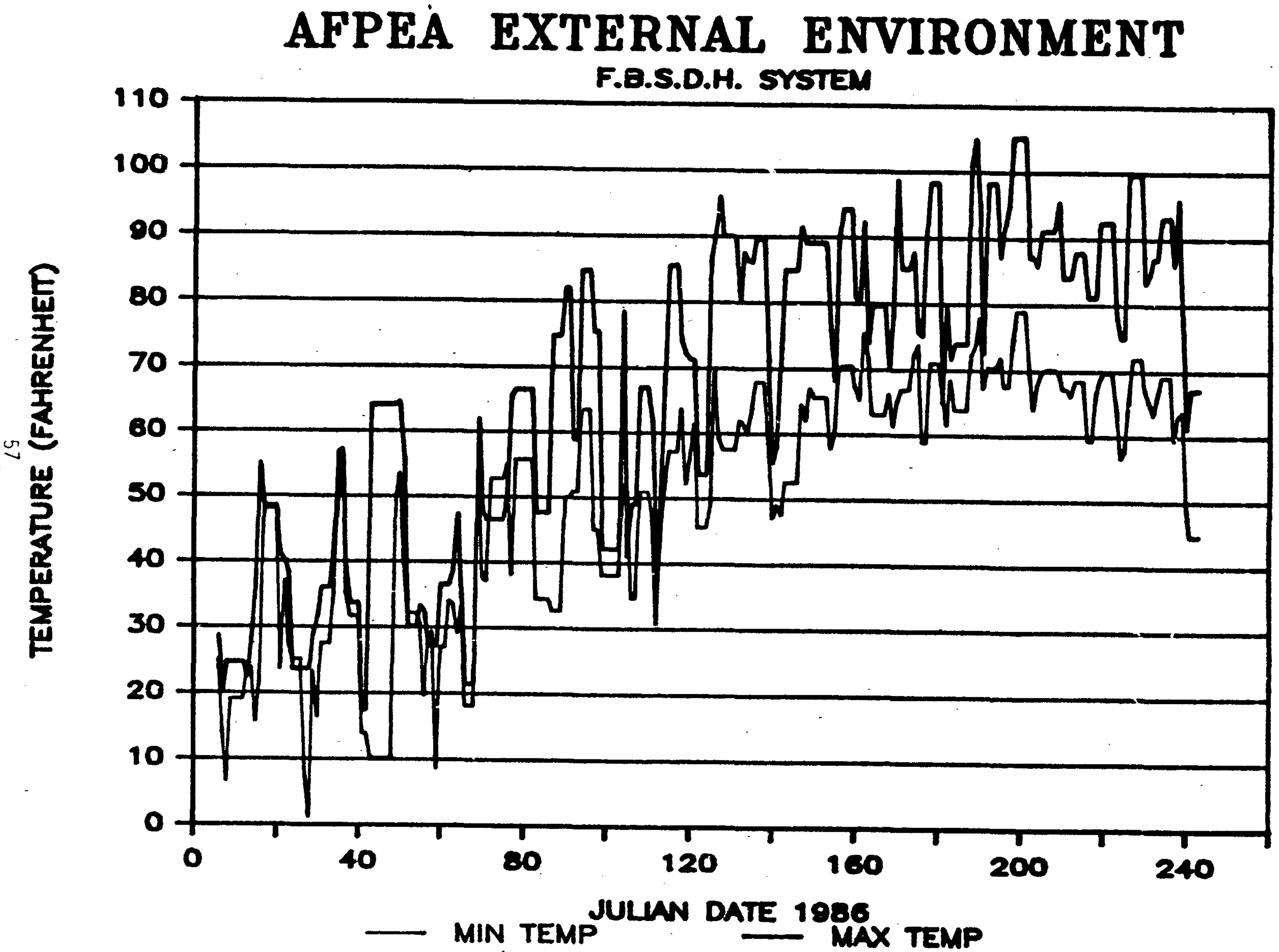
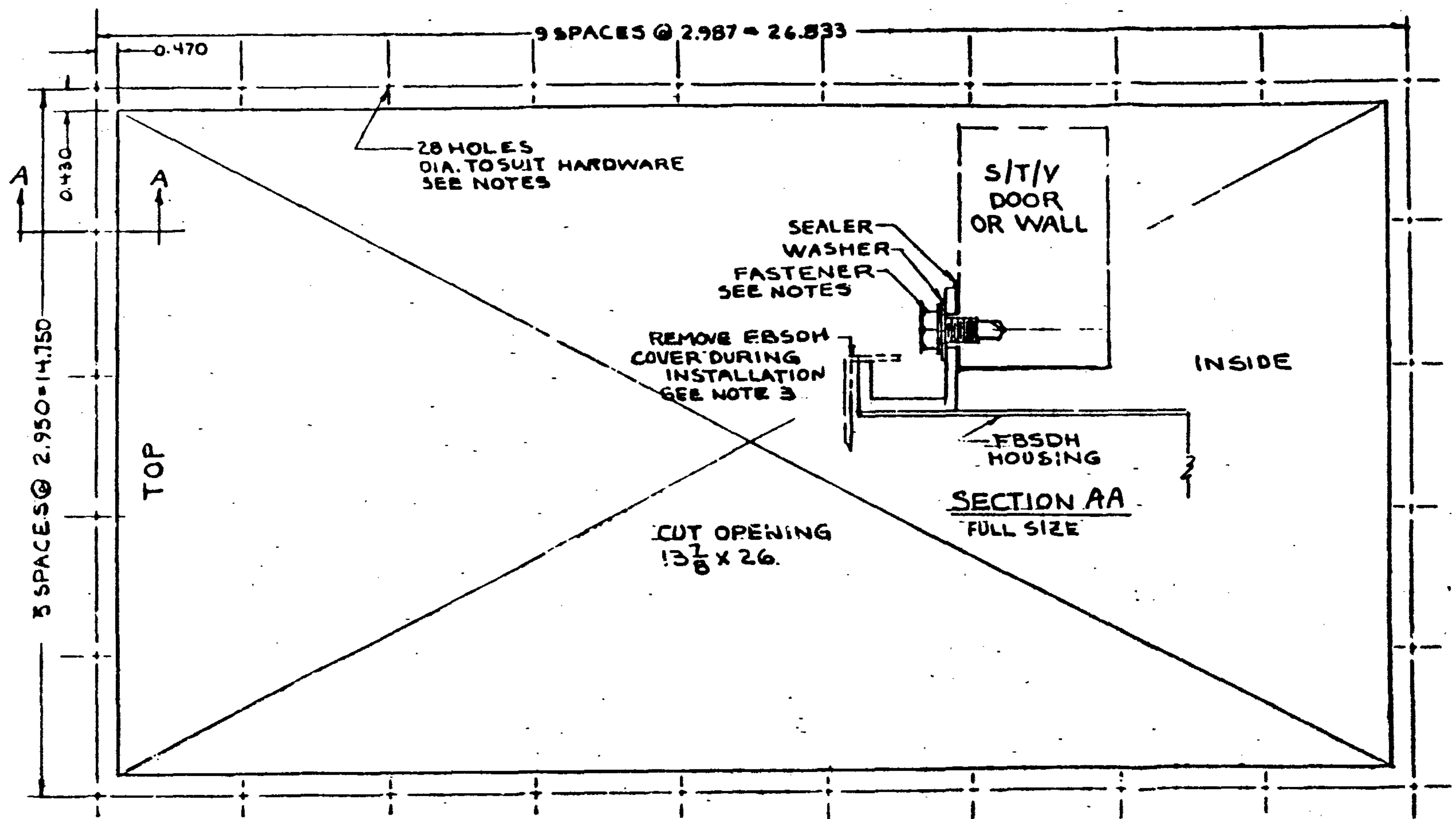

AFPEA EXTERNAL ENVIRONMENT
F.B.S.D.H. SYSTEM
TEMPERATURE (FAHRENHEIT)
110
100
90
80
70
60
50
40
30
20
10
0
0
40
80
120
160
200
240
JULIAN DATE 1986
MIN TEMP
MAX TEMP

Figure 31



NOTES

1. THE FBSDH HOUSING MAY BE USED AS A TEMPLATE FOR HOLES. THE HOUSING SHOULD BE CENTERED IN THE CUT-OUT BEFORE DRILLING MOUNTING HOLES IN S/T/V STRUCTURE.
2. STAR "DRILL&TAP" SCREWS, BOLTS AND NUTS OR RIVETS MAY BE USED. HOLES IN FBSDH MOUNTING FLANGE ARE 11/32"DIA TO PROVIDE LIBERAL CLEARANCE FOR 1/4" HARDWARE. HARDWARE IS NOT FURNISHED BY AGM.
3. FOR CONVENIENCE THE FBSDH COVER MAY BE REMOVED DURING INSTALLATION.

TEMPLATE FOR INSTALLATION OF FBSDH

1/2 SIZE

Figure 32

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AFALC/OA Wright-Patterson AFB OH 45433	2
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